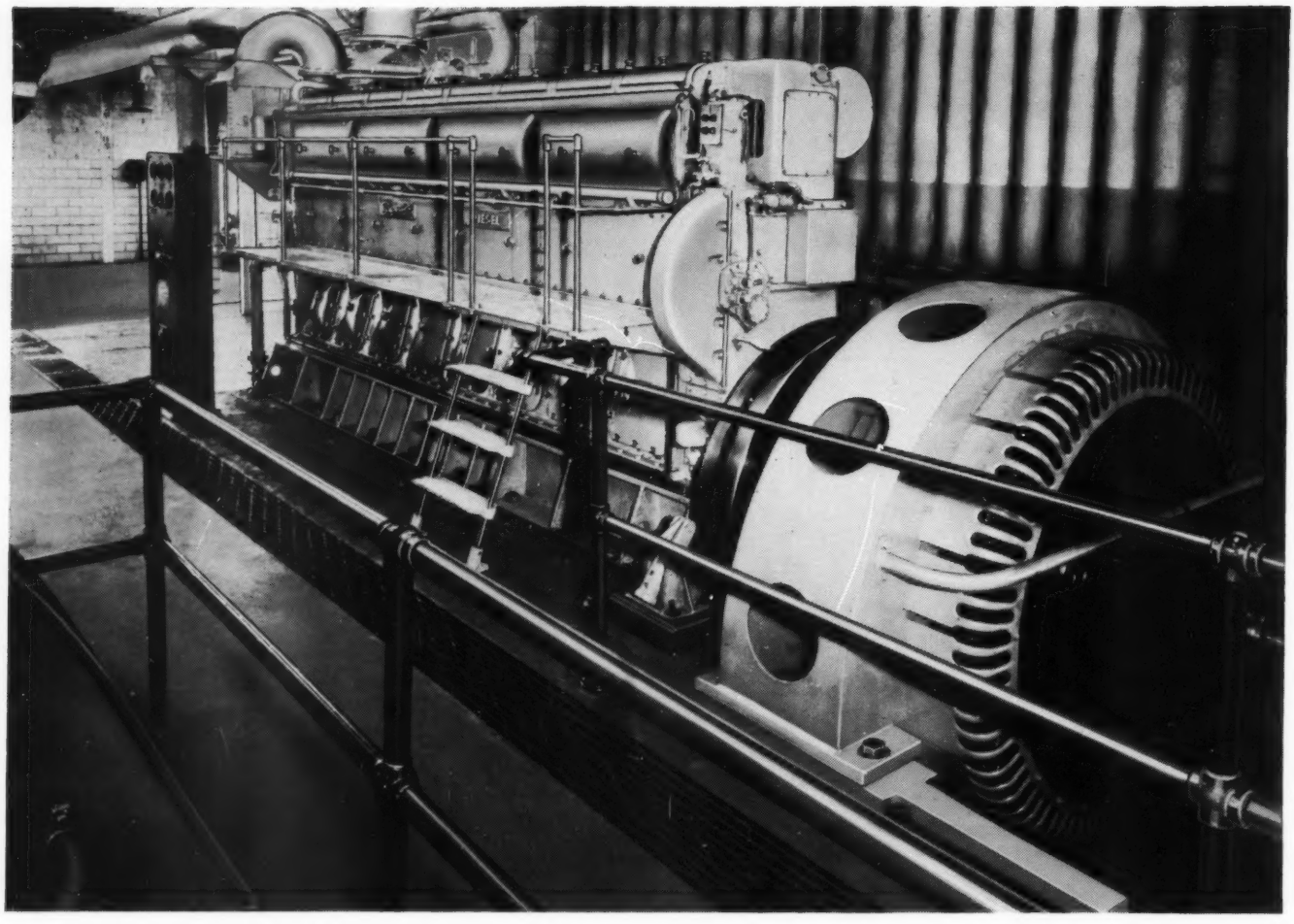
consulting engineer

A Rod And A Staff

DUANE COUZENS HORMELL is the newest vice president at Pioneer Service & Engineering Co. As he sees it, the biggest part of his job is men. The most valuable asset of any consulting firm lies in the capabilities of the men on its staff, in

— Continued on page 6

February 1955



Not yet "broken in"... but producing over 14 K.W.H. per gallon!

That's the report on this new Superior Model 65 Diesel recently installed in the Petoskey, Michigan, power plant. This record of high level performance at low operating costs—even under widely oscillating load—is typical of the Model 65.

Designed to pack more horsepower into less weight and space, this Superior Model 65 keeps building and installation costs down. You'll find that fuel costs are low, too, especially when it's equipped for dual-fuel operation. By simply pushing a button, you can switch between diesel and sewage (or other by-product) gas.

There's long life in the structure of the Model 65, too. From its heavy-duty, welded steel block to its alloy iron cylinder heads and advanced fuel system, you'll find only the finest in materials and craftsmanship—the quality that only its maker's 100 years of engine building experience can provide.

Whether you're interested in diesels for generator, pump, or other drives, you'll want complete facts on the Superior Model 65. Just write or stop in at the nearest office listed below.

IMPORTANT FEATURES OF THE SUPERIOR MODEL 65

- Fuel economy is a fact with this precision-built 4-cycle heavy-duty engine. Improved combustion and scavenging are two of the reasons.
- Long-lived Superior engines consistently produce lowest overall power cost, by fewer parts replacements and lower maintenance.
- All models can be specified for Dual Fuel operation (by-product gas and diesel fuel oil).
- Maximum accessibility to all operating parts for simple and easy maintenance.
- Available in both 6 & 8 cylinder models, naturally-aspirated or supercharged.
- Size to fit any need from 420 to 1250 KW, or 580 to 1765 BHP.

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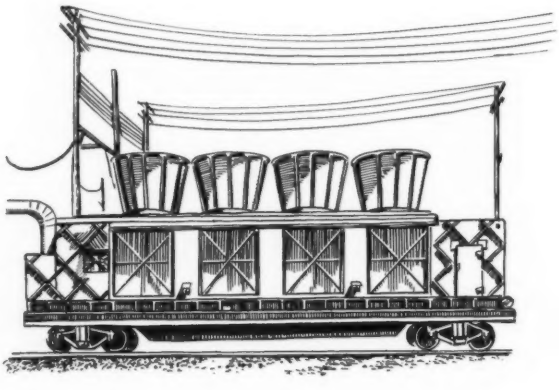
BPA

D. C. Hormell

— Starts on front cover

Hormell's opinion. Anything a firm can do to keep its good men results in the retention of their background and talents plus the skills taught to them by the firm. In no way, aside from retaining its experienced men, can a consulting firm earn any dividends from the investment in training it must inevitably make in every man. So thinks Hormell.

He points to the effects of the Great Depression to illustrate his point. Many consulting firms failed then. Among those who managed to maintain an office, few were able to keep many of their key engineering people. When World War II came along, there were too few mature engineers on their staffs who had accumulated 10 or more years of experience. There were few old-timers over whose shoulders younger men could look and learn the company's business.



Hormell thinks we are just now coming into a period when the age distribution among engineers permits maintaining a balance compatible with the needs of a well-rounded consulting team—balanced with respect to having the optimum number of experienced hands who can pass along the benefit of their years to the younger men coming up. The age distribution in any consulting firm, he thinks, has to be such as to insure that adequate numbers of qualified men are always on the way up, and that the experienced men do not retire all at once.

These problems of staffing a firm are not insurmountable. Hormell points to Pioneer as having lower-than-average turnover. He feels that the firm benefits greatly from it. He heartily subscribes to the means used by his company to make it a good place to work: contributory retirement plan, life insurance, hospitalization, surgical and medical insurance, and semi-annual performance and salary review. Ownership of company stock is possible for engineers and supervisors. All employees participate in a profit-sharing plan when earnings justify it. These and other elements of the company's program tend to make the engineers, supervisors, and employees an important and integral part of the firm.

Perhaps most important to retention of Pioneer's staff is a sincere desire of the engineering executives to inspire and develop men for tomorrow. They are encouraged to further their educations, to write papers, and join professional societies. Hormell believes young engineers should be directed and encouraged to develop along lines for which they are best qualified. Further, he feels that men must be trained not only to work but to become leaders in their field. His company is continually seeking better ways to develop its staff, both in engineering and in human relations.

These thoughts have 40 years of experience behind them. Hormell spent two of his college summers as a rodman with a railway surveying party. He graduated from West Virginia University with an M E degree and went right to work in the utility industry. He was indoctrinated in the boiler room, became an electrician's helper, put in his time on the drafting board, and worked in construction. While associated with the W. S. Barstow Management Association as project engineer, he worked on the engineering and design of a number of electric generating stations for utility companies.

In 1930, he joined Byllesby Engineering and Management Corporation, the firm that ultimately became Pioneer. He did central station design for such companies as Louisville Gas and Electric, Northern States Power, Duquesne Light, Oklahoma Gas and Electric, Wisconsin Public Service and San Diego Gas & Electric. Pioneer Service & Engineering Co. came into being in 1948, and Hormell was made its chief mechanical engineer. Last year he was made vice president and chief engineer.

He looks back on two achievements with particular interest. He developed the first sectionally supported refractory furnace wall, and he served as consulting mechanical engineer to Westinghouse Electric Corporation in connection with power trains built during World War II for the Russian government. The power train job he recalls quite vividly because the Russians insisted on the very best of designs, materials, and methods — almost to the point of luxury in days when wartime urgency was the general rule. He is not sure where the Russians picked up their sophisticated tastes in engineering, but he has a hunch that what they really wanted were good models from which to copy.

All in all, a full career in the utilities field, an insight into the needs of the engineering profession, and an awareness of the legacy due his juniors—these mark the daily routine and the professional life of Duane Couzens Hormell. ▲▲

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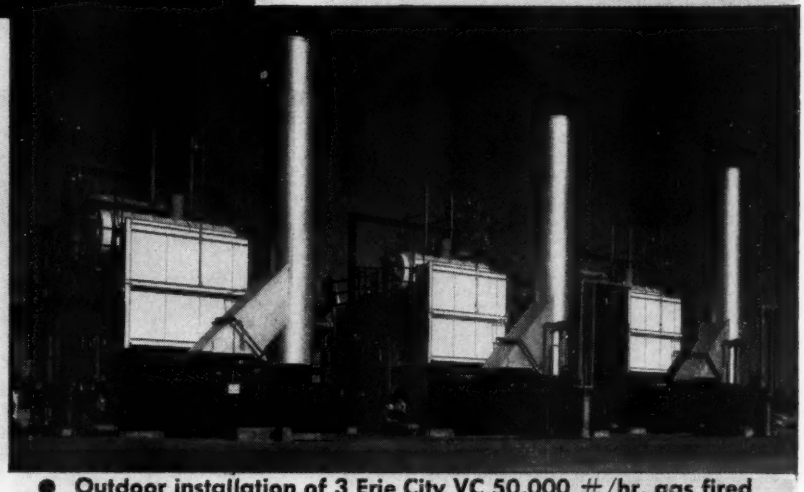
The air is washed clean of carbon dioxide with caustic; compressed, dried, and liquified. The liquid air is fractionated, and the overhead nitrogen product is one of the basic materials for ammonia synthesis.

Water is added to three Erie City VC Steam Generators and becomes steam. Part of this steam reacts with natural gas in a reforming furnace. The effluent gas contains hydrogen, oxides of carbon, and methane. The flue gases from the furnace are used as a source of waste heat to operate two Erie City VL steam generators. The steam from these generators augments plant steam requirements at low cost.

Carbon dioxide is removed from the reformed gas by scrubbing with a liquid amine solution, recovered, and processed to form dry ice. The carbon monoxide and methane are removed by scrubbing with liquid nitrogen. The overhead product from the nitrogen wash column is a mixture of hydrogen and nitrogen ready for the synthesis operation.

Ammonia from the Brea process provides the foundation for servicing the farmer with aqua ammonia, aqua ammonium phosphate, and ammonium sulfate, and in the near future—ammonium nitrate.

Erie City through the application of sound engineering in the design of its products, is proud of the part it plays in this new petrochemical industry.



● Outdoor installation of 3 Erie City VC 50,000 #/hr. gas fired Steam Generators at Brea Chemicals, Inc.

● Outdoor installation of 2 Erie City VL Waste Heat Boilers fired by flue gases from the Reform Furnaces shown above.

● Air view of the Brea Chemicals Inc. Ammonia Plant at Brea, Cal.

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10 BEST ANNUAL HEAT RATES

(Plant Net Heat Rates)
Btu per kwhr*

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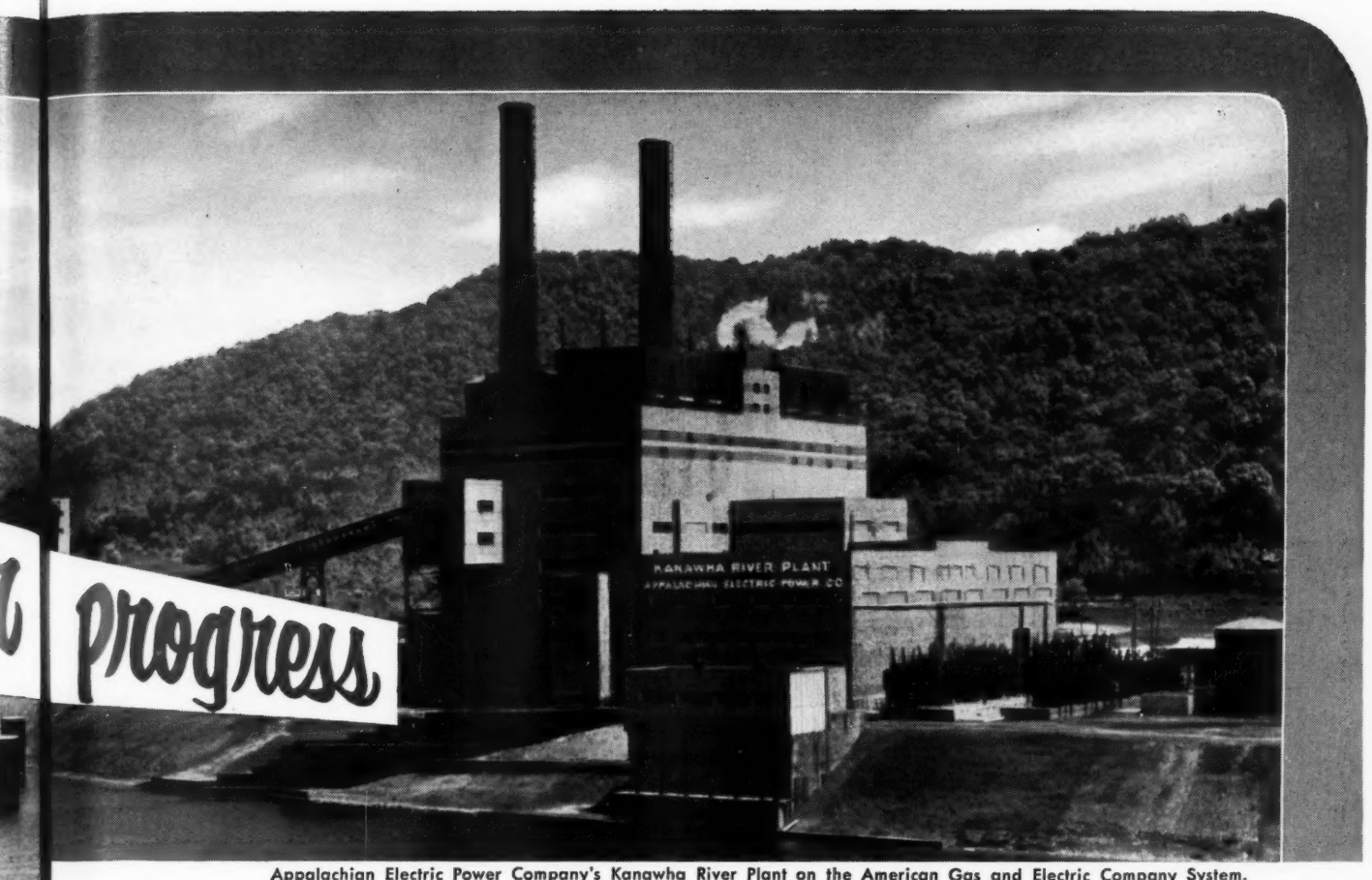
9329 TANNERS CREEK	**Indiana and Michigan Electric Co. on the American Gas and Electric System—** Three B&W Pressure-Fired Radiant Reheat Boilers with Gas Recirculation and Divided Furnace Construction.
9418 ALBANY	**Niagara Mohawk Power Corporation.**
9454 SCHILLER	**Public Service Co. of New Hampshire—** Two B&W-built Mercury Boilers.
9510 DUNKIRK	**Niagara Mohawk Power Corporation.**
9540 J. R. WHITING	**Consumers Power—** Three B&W Radiant Reheat Boilers.
9594 PHILIP SPORN	**Appalachian Electric Power Co. and The Ohio Power Co. on the American Gas and Electric System—** Four B&W Pressure-Fired Radiant Reheat Boilers with Gas Recirculation and Divided Furnace Construction.
9630 ST. CLAIR	**Detroit Edison Co.—** Four B&W Radiant Reheat Boilers with Gas Recirculation and Divided Furnace Construction.
9661 EASTLAKE	**The Cleveland Electric Illuminating Co.**
9815 ASTORIA	**Consolidated Edison Co. of New York, Inc.—** Two B&W Pressure-Fired Radiant Reheat Boilers with Gas Recirculation and Divided Furnace Construction.

* Federal Power Commission figures



Appalachian Electric Power Company's Kanawha River Plant on the American Gas and Electric Company System.

Headed by a record 9170 Btu per net kwhr, these ten plants were the most efficient central stations in the country during 1953, the most recent year for which complete heat rate data are available.

Reflecting the decision of the electric companies to utilize the most recent engineering advances, even during a time of critical capacity expansion, the outstanding performance of these modern plants is a tribute to the foresight of the whole industry. It affords one more indication that the prime interest of this unique team of electric companies and their major suppliers lies in producing still lower-cost kilowatts for a still greater America.

B&W Boilers in many of these stations are designed with such advances as Pressure-Firing, Cyclone Steam Separators, Gas Recirculation and Divided Furnace Construction — features which have contributed substantially toward the outstanding efficiency levels achieved. Also, all steam generating units are equipped with reheaters, a development of major importance in improving plant efficiency.

Pressure-Firing

Among the many advantages of this important engineering advance, as utilized, for example, by the Kanawha River units, is elimination of air infiltration to reduce stack loss and assure greater efficiency. Maintenance is reduced and the use of forced-draft fans alone means easier starting, smoother operation and simpler controls. These are the reasons why more than 100 Pressure-Fired B&W units are now in service or under construction.

Cyclone Steam Separators

Operating inside the steam drum, these simple, stationary devices require no power or maintenance and do not take up building room. The Cyclone Separators assure positive natural circulation at high pressure, and with the steam scrubbers, make it possible to send steam of highest purity to the turbine. Consequently, turbine efficiency is maintained and turbine outages reduced.

Divided Furnace Construction

With this B&W construction, building volume is held to a minimum. Both sides of the furnace division wall are used to absorb heat and thus make it possible to achieve the required furnace cooling surface without excessive increase in building volume.

* * * * * *

The record heat rates set by these leading generating stations are closely followed by those of many more plants across the country which are producing low-cost kilowatts at efficiency levels unattainable just a few years ago. And B&W is continuing to devote its energies and its long-accumulated experience to the development of boiler designs that will contribute to still higher levels of steam generating efficiency. The Babcock & Wilcox Company, Boiler Division, 161 East 42nd Street, New York 17, N. Y.

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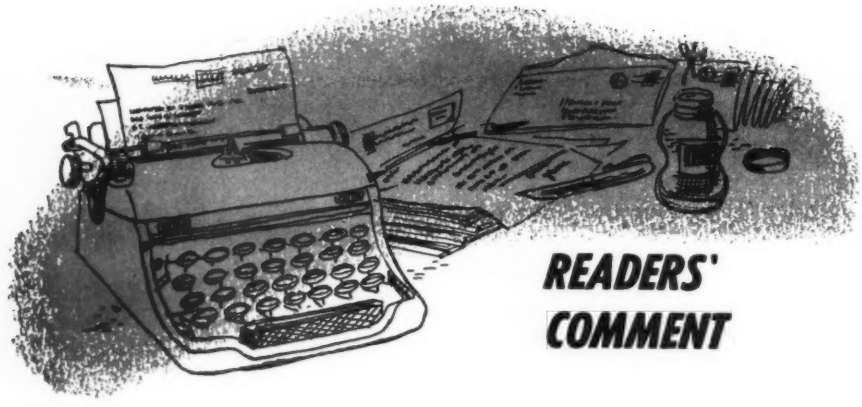
BOILER DIVISION

G-696



READERS' COMMENT

Missing Credit Line

The January issue of CONSULTING ENGINEER, which is referred to on the cover as "the consulting engineer's professional magazine," has just been received and is even more interesting than usual, especially the ["Survey of the Profession" and "You've Got To Be a Joiner"]. However, some of the interest has been diluted for us by reason of the article on page 62 which refers to the [South Park Avenue Bridge].

The South Park Avenue Bridge was designed by this office and the construction is nearing completion under our supervision and inspection. Porcelain enameled steel enclosures for the machinery houses on the tops of the towers were selected by us after considerable study, not to combat "erosion" but to combat "corrosion," and the products of the Erie Enameling Company were mentioned in the specifications as a standard of quality. Erie Enameling Company, a subcontractor for this work, requested permission to take photographs for publicity purposes which was granted with the understanding we would be given a suitable credit line. Therefore, it is a little disappointing to read the article as written, although it is only fair to say that the materials, workmanship and service furnished by Erie Enameling Company were very satisfactory.

To make the story more nearly complete, the bridge is being built by Frazier-Davis Construction Company, St. Louis, Missouri, as general contractor, with the following principal subcontractors:

Structural Steel and Mechanical Equipment—American Bridge Division, United States Steel Corporation.

Electrical Equipment and Installation—Westinghouse Electric Corporation and Buffalo Electric Company, Buffalo, New York.

Elevators — Otis Elevator Company.

A. Stuart Collins
Consulting Engineer
Buffalo 2, New York

● WE HERE GIVE CREDIT WHERE CREDIT IS DUE. ERIE ENAMELING FORGOT THAT OTHERS WERE INVOLVED.

Definite Try

Your magazine is very interesting and we enjoy receiving and reading each issue.

Here is a question which you could help settle: What is the definition of a Consulting Engineer? You could probably collect a hundred definitions, but certainly there must be one that would be generally acceptable. The following is what we have developed:

A consulting engineer is a licensed or registered engineer actively engaged in private practice, receiving assignments from private or public agencies; he has a monetary investment in his firm, carries responsibility as a principal, partner, officer or associate, and exhibits good character and reliable habits.

Note that the definition refers to a financial investment in the business. This seems so much a connotation of the word that is usually forgotten, and it also differentiates between the principal or employer and the employee.

Frank A. Randall, Jr.
Frank A. Randall & Sons
Chicago 6, Illinois

● ANYONE WANT TO TRY ANOTHER DEFINITION?

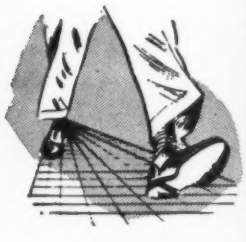
Serving a Need

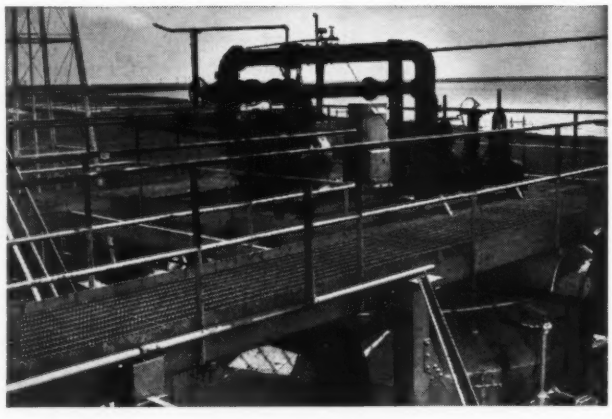
Your CONSULTING ENGINEER serves a genuine need of engineers for such a publication. The material as selected for the periodical is of interest not only to engineers engaged in private practice, but also to engineers employed by various firms and organizations.

You deserve to be congratulated for the splendid periodical, and we trust that you will continue. . .

Steven Antonoff
Steven Antonoff & Associates
Detroit, Michigan

WHERE **SURE FOOTEDNESS** COUNTS





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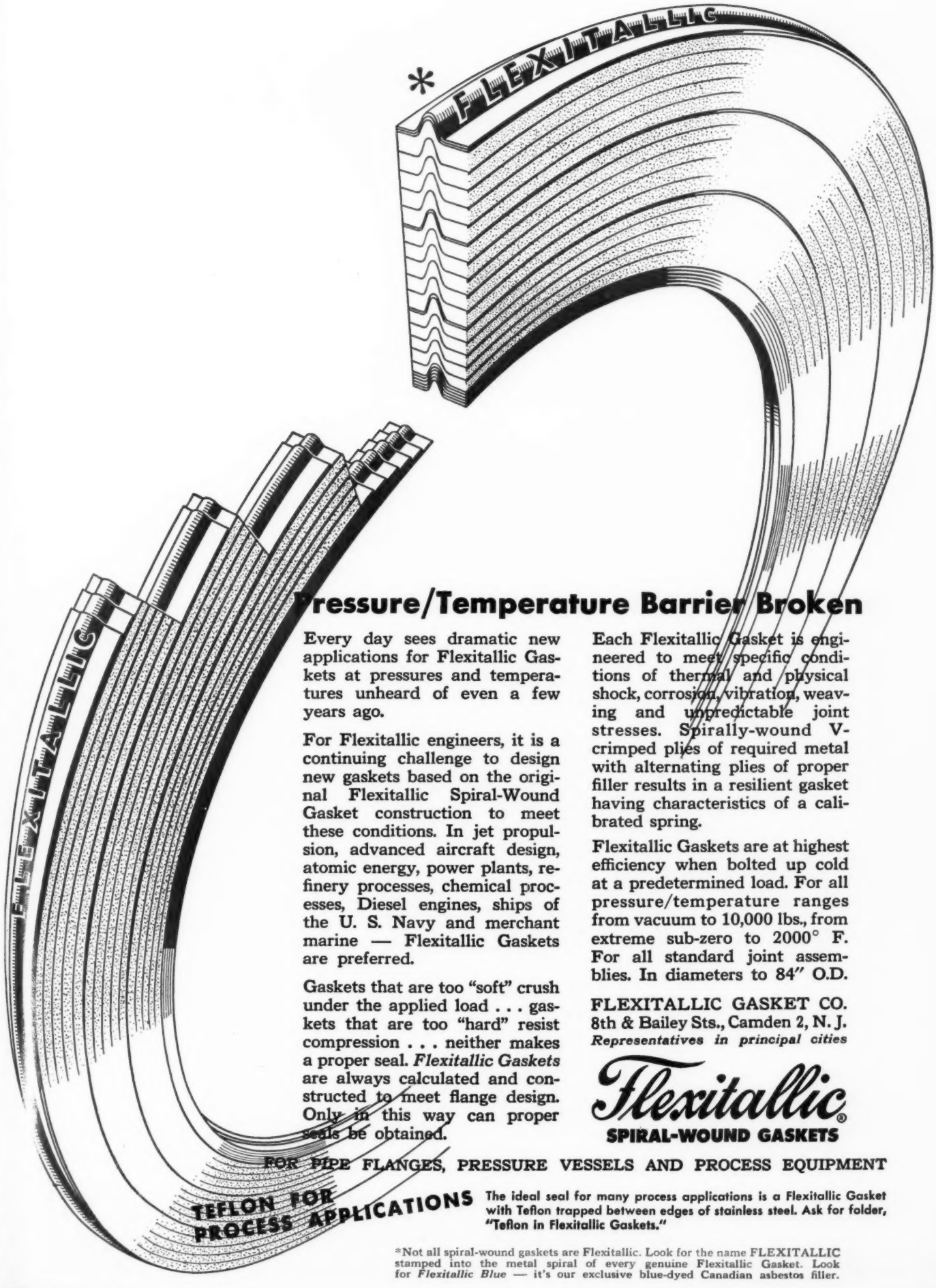

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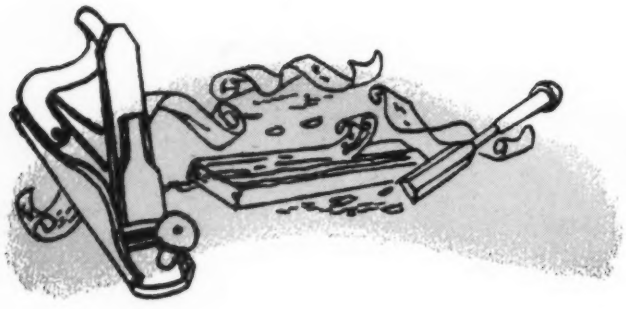

SCRAPS & SHAVINGS

IT WAS SOMEWHAT of a surprise to find an article in the January issue of *Harper's* pointing out "The Trouble with Engineers". *Harper's* is generally considered something of an intellectual or literary magazine. It has been determined in one type of test that it takes a person with a full high school education to read *Harper's* with complete understanding (as opposed to 6th grade level for *True Story).*

The author of the article, Mr. George S. Odiorne, is head of the Management Service Section, of Rutgers University. He has a lot of interesting things to say about "The Trouble with Engineers," and some of the things he says are correct. More interesting are the things he says that are wrong. Mr. Odiorne is telling the truth, no doubt, when he says that he "informally" checked the Sunday *New York Times* and found that fifteen of the fifty-odd columns of Help Wanted ads were for engineers, topping even the eleven columns for salesmen. However, Mr. Odiorne failed to mention the salaries being offered. We have made a check (equally as informal as Mr. Odiorne's) of the *Chicago Tribune.* Our investigation delved into salaries offered rather than column-inches of space. We found that salaries for salesmen ran from $7,000 to $20,000, with a median of about $11,000. This compared with salaries for engineers from $5,000 to $12,000, with a median of about $7,000. It was worth noting that the upper salaries for "engineers" were invariably for managers or executives with engineering background rather than for engineers hired to do straight engineering work. It would take a real economist to decide whether Mr. Odiorne's column-inch investigation or our salary level study is more accurately indicative of true conditions.

Getting into the real "Trouble With Engineers," the author comes to the conclusion that engineers have a tendency to isolate the engineering profession from both science and business. This, he says, is taught to the young engineer in school, then, when he goes out into the world of reality, "Idea by idea, he must clear his mind of 'pure' engineering in order to make way for such mundane considerations as cost, marketability, consumer foibles, company folklore, union contracts, and the personality quirks of the chief engineer."

Bosh! If the young engineer is so lacking in understanding of costs, marketability, and consumer foibles, then why do the largest manufacturers in this country fight each June for engineering graduates for their sales staffs . . . and pay them more on selling jobs than on straight design or production.

As a solution to the "trouble," Mr. Odiorne comes back to the old saw about broadening the engineer's education to include the humanities, arts, and social sciences. Numerous engineering schools, he points out, have turned their efforts in this direction, by associating with colleges, and the engineering graduate receives two degrees at the end of five years —a Bachelor of both the Arts and Sciences.

To our way of thinking, this combination is about as valuable to our industrial economy as a degree in Appreciation of Occidental Art from the University of Pieping. Under a straight four or even a five year course in engineering, there is all too little time to teach the engineer the fundamentals of applied science, which, incidentally, include instruction in the importance of "cost," and "marketability." To try to toss in a Bachelor of Arts degree in the same college course is diluting both to the weakness of hot-water tea.

It has long been a contention of many outside the engineering profession that engineers are "Skilled Barbarians," to use Mr. Odiorne's words. If this is a true evaluation, then Bachelors of Arts can accurately be termed "Unskilled Barbarians."

We believe it to be true that an inclination toward the arts, philosophy, or abstract intellectuality, is something generally developed in precollege years. The course the college student takes—law, engineering, medicine, or a degree in the arts—does not determine his cultural interest. Quite the reverse. His adolescent cultural interest more probably determines which college course he takes—and for that reason we do find a higher percentage of those with developed cultural interest taking non-professional courses in college.

But fear not that the engineer is a "Skilled Barbarian" simply as a result of his engineering education or the influence of his professional elders. Whatever cultural or social interest he has, he will develop as well as the next man.

What we need right now is more intense education in what Mr. Odiorne terms 'pure' engineering. We can manage the culture without the aid of an additional degree in Arts.

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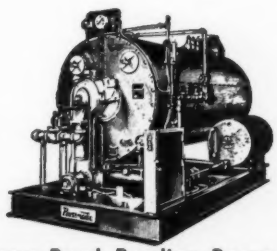

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Established 1885 • Morgantown Road, Reading, Penna.

the Legal Aspect

MELVIN NORD
Consultant in Legal and Technical Problems
Registered Professional Engineer
Patent Attorney

. . . masters, servants, contractors

WHEN TWO parties enter into a contract, they are at "arm's-length." Each should be looking out for his own interests, and protecting himself as well as he can. Neither party is under any obligation to look out for the interests of the other.

While arm's-length transactions are the very essence of business in our form of society, not all transactions are of this type. There are closer relationships than this — relationships in which the parties are not at arm's length, but are "locked in a fond embrace." The "master-servant" relationship is of this type.

Virtually Defenseless

In the master-servant relationship, with the parties having their arms around each other's shoulders, each is nearly defenseless against the other. As a result, the law regulating this situation is fundamentally different from the law relating to such arm's-length transactions as contracts.

Generally speaking, there are two types of relationships possible when the parties are "locked in a fond embrace." The parties may be primarily attempting to advance the interests of *one* of them, or they may be seeking to advance the interests of *both* of them. The master-servant relationship and all fiduciary relationships, or relations of "trust," are basically of the first type. Partnerships are of the second type.

Must Have Servants

The master-servant relationship is of immense importance in industry, and especially so in the type of industry with which engineers are concerned. No person can operate an industrial enterprise by himself. Many people are required. Because they cannot all be equal partners, some must be "servants" in the legal sense. Anyone who has a job is legally in this status. This includes lathe operators and college presidents. Only those who are "self-employed" (or not employed at all) are outside of this class.

Whether the relationship between two parties is of the master-servant type or of the independent contractor type is a question of fact. It depends on what the parties intended. The law does not tell us whether or not the parties have entered into a master-servant relationship. The law merely tells us what the legal consequences are when the parties have *in fact* entered into such a relationship.

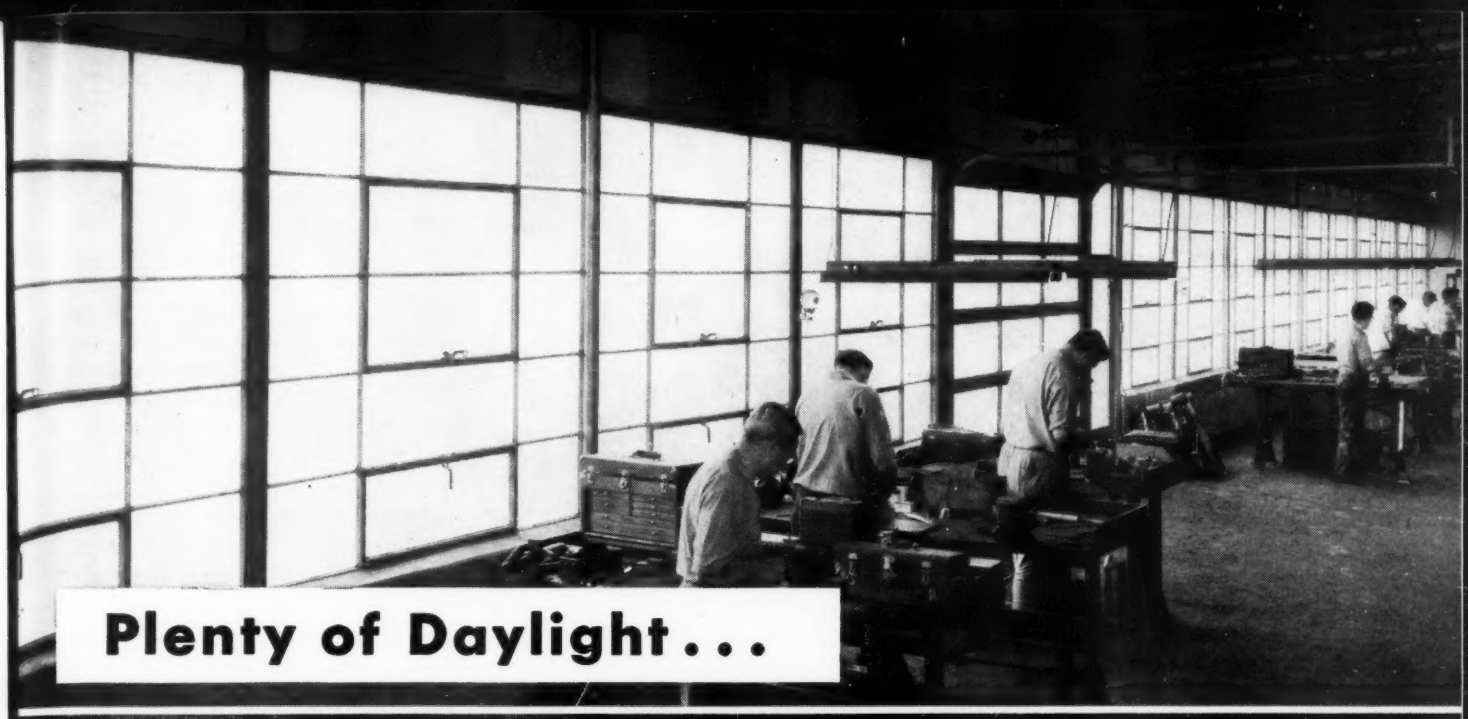
The principal test of the existence or non-existence of the master-servant relationship is the right of one person (the master) to control the performance of certain work by the other (the servant). If the person doing the work can be held responsible only for the final result, but cannot be directed as to the manner of doing the work, he is not a servant but is an independent contractor.

A Case In Point

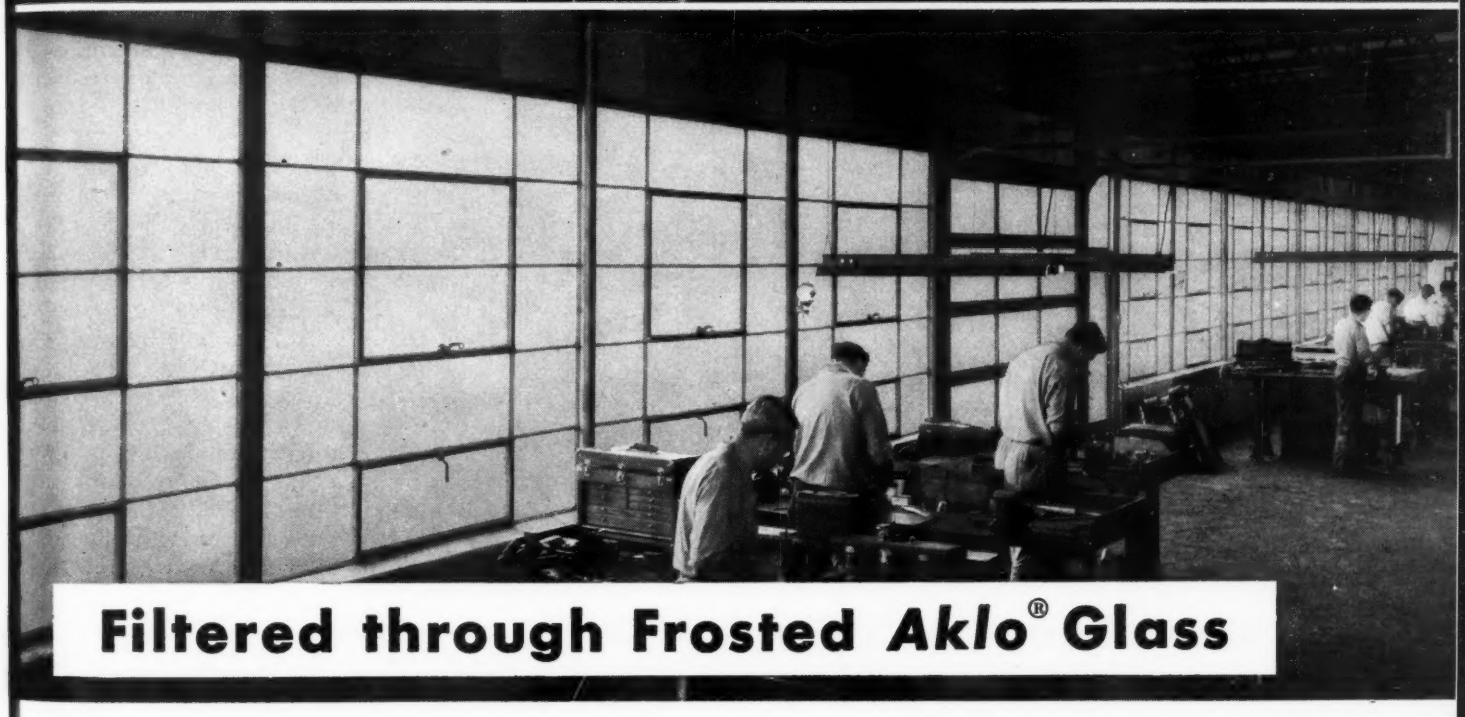
To illustrate the point, consider the case of *James v. Ellis et al*, 269 Pac. (2d) 573, a State of Washington case decided May 28, 1954. Ellis was employed by Brandt Brothers Roofing Co. On reporting to work at the shop at 7 am, he was told that he and several other men would work that day, as they had the previous day, on a roofing job in the nearby town of Newport, Wash.

Ellis had used his car in transporting himself, four other men, their tools, and their work clothes to the job the day before. He did so again this day. According to the terms of the union contract, employees were paid 10¢ a mile for the use of their cars in such cases. The men's pay started at 7 am, and included travel time. The company did not specify the route to be taken.

The trip was interrupted by an accident in which a pedestrian was struck by the right front fender of the car while she was crossing the street in a crosswalk. The company was joined as defendant in a suit for injuries. It defended itself on the ground that there was not proof of a master-servant relationship at the time of the accident. The company



Plenty of Daylight...



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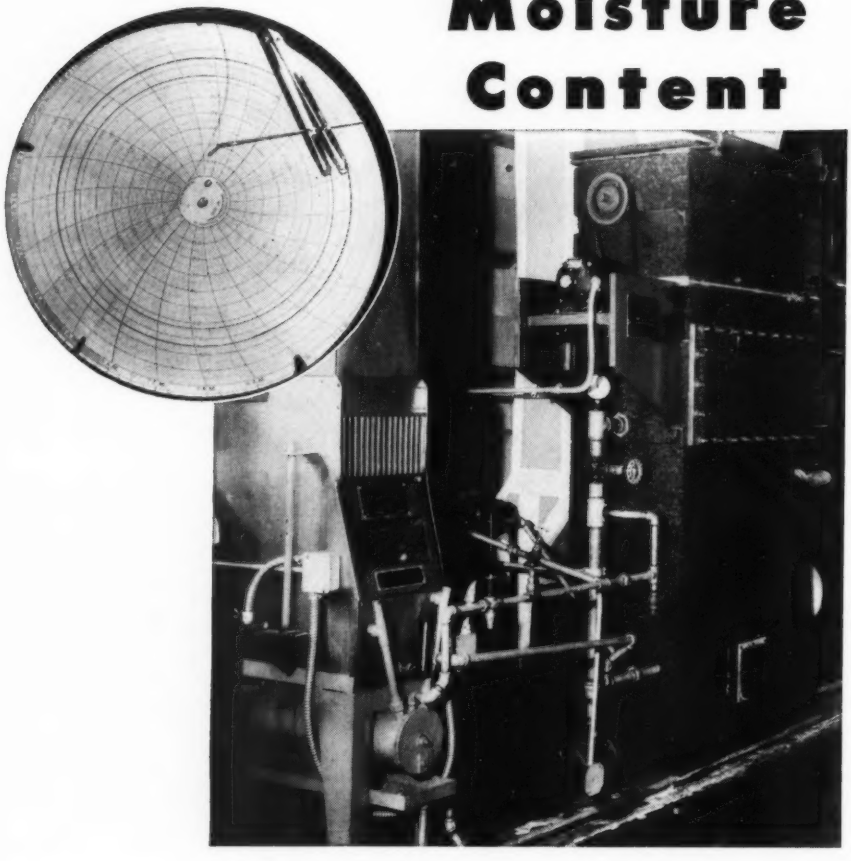

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contended that Ellis was not directed as to the *route* to take, but only that he accomplish the result of getting to the job site.

The court held for the plaintiff, however, saying that the company had the *right* to control the route and the method of transportation. It is irrelevant whether or not the company *exercised* that right. "The *right* to control is the test of the relationship." Nor was the defendant's claim accepted that there was an independent contract for the transportation. "The union contract . . . simply defines the rights of Mr. Ellis, in the event he used his automobile to further his employer's business."

Faithfulness

When the master-servant relationship exists, the employee or servant is held to a high standard of faithfulness to the employer, or master. He must obey all reasonable rules, orders, and instructions relating to the work. He is not permitted to make a profit in the course of the employer's business that might otherwise have been made by the employer. If he does, the employer can recover the profit in an action at law, if necessary.

A good illustration is the case of *Cornale et al v. Stewart Stamping Corp.*, 129 N.Y. Supp. (2d) 808, a New York case decided Feb. 27, 1954. The Stewart Stamping Corp. is engaged in the manufacture of stampings and small metallic parts used in the electronic industry. Duarte became an employee in 1939 and was promoted to foreman of the tinning and plating department in 1941. Among his duties, he advised the company concerning soldering fluxes, and made written requisitions for his flux requirements.

In 1948 he advised the company that the commercial flux which the company had been using since 1943 was not desirable because it was injurious to the hands of the employees. In the latter part of 1948 Duarte made his own flux at the plant. The use of this flux was also discontinued upon his advice.

Later, he went into partnership with Cornale to produce soldering flux, based on his experiences with Stewart. Duarte and Cornale

organized the Foamflux Company for this purpose in 1949, as a partnership. Duarte's role in the Foamflux Company was kept secret, and he continued to work for Stewart. He requested the exclusive use of the Foamflux product between 1949 and 1952, when he was discharged. During this time, the sale of flux by Foamflux to Stewart amounted to $35,-772.29. Foamflux had virtually no sales to other users during this time. The profits on the sale of flux amounted to $25,908.11.

Cornale and Duarte divided $18,094.25 of the profits between them. The remainder of the profits was invested in Westchester Products Co., a company they organized in 1950. Duarte's role in this business was also kept a secret. The new company constructed machines virtually identical to the ones in operation at Stewart, and engaged in a competing business while Duarte remained in the employ of Stewart. Westchester claimed that the machines were based on a patent and hence were not a trade secret, but it was shown that both machines departed from the patent in the same way. It was admitted that Duarte assisted in the construction of the machines.

Suit and Counter-Suit

Cornale and Duarte brought suit against Stewart to recover flux sold to the company and not paid for. The company countered with its own suit to recover the profits made by Cornale and Duarte out of the flux business and out of the competing Westchester business.

The court held for Stewart, directing Cornale and Duarte to pay Stewart the profits of $18,094.25 which they had divided. It also impressed a trust on the machines and assets of the Westchester Products Co. The court refused to allow Cornale and Duarte any recovery whatever for flux delivered but not paid for.

As the court said, "No man can serve two masters with equal fidelity when rival interests come into existence. Employees are bound at all times to exercise the utmost good faith and must act in accordance with the highest principles of morality." ▲▲

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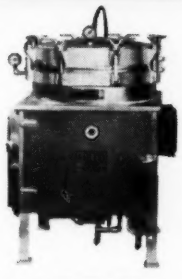

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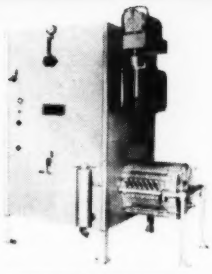

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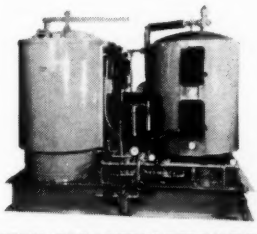

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ECONOMIC NEWS NOTES

E. F. Mac Donald
INDUSTRIAL ECONOMIST

BELTLINE TRANSPORTATION — It has been reported that Riverlake Belt Conveyor Lines, Inc., is trying for the third time to persuade the Ohio legislature to extend it the right of eminent domain for the construction of a 100-mile ore-coal conveyor belt from Lake Erie to the Ohio River. Conveyor belts will get their big test in the passenger field next year when they take over from subway rail-trains the job of shuttling the jam-packed traffic between Times Square and Grand Central Station.

IN AGAIN, OUT AGAIN — One of the fastest-growing developments in the postwar progress of the utility industry has been the vast expansion of underground storage of natural gas. It is estimated that there are now 167 storage fields in 17 states, with 12 more pools under construction. Present reservoirs provide a storage capacity of two trillion cu. ft. of gas and have revolutionized winter peak-supply problems for many cities.

CONSTRUCTION EMBARGO — Upon assuming office at the outset of this year, Governor Harriman, of New York, issued instructions that for the time being, no new construction contracts should be awarded. He declared, "The State government has actually been living beyond its income for several years, spending more than it has received. The day of reckoning has arrived." Among other projects of interest to construction, Governor Harriman endorsed a $750-million bond issue for road building, recommended a $90-million subsidy increase for public projects, and called for a "neighborhood conservation" program to check slum growth.

OPERATION BOOTSTRAP — "How Localities Can Develop a Workable Program for Renewal" is an outline of the up-and-coming municipal program of clearing out slums for rebuilding a replanned city. It is available from the Housing and Home Finance Agency, Washington 25. Here's a go-forward type of project that could work out to the benefit of all parties—individuals, business, and the city.

TARHEEL GROWTH — General Electric announced last month that it will construct a $20 million plant in the Hickory-Newton-Conover area of North Carolina for the manufacture of distribution transformers. The plant, to employ 1,100 workers, will be the 12th one located by GE in the South. Since 1939 employment in North Carolina's electrical and electronic industry has increased from a piddlin 66 workers to an impressive 22,000. Significantly, this is the kind of industrial diversification that the North Carolina economy needs to correct the heavy concentration of manufacturing employment in textiles, lumber, furniture, and tobacco.

BIGGER 'n BETTER — Forecasting a record volume of construction outlays this year, the Associated General Contractors of America looks for the total to reach $56 billion, $4 billion more than the 1954 construction bill. This organization, representing some 6,500 construction firms throughout the nation, expects new construction outlays to add up to $40 billion and repair and maintenance projects to amount to $16 billion. Increases in residential, institutional, and commercial building and in public works are foreseen far offsetting moderate declines in farm, Federal, and industrial construction.

WARNING NOTE — Builders were warned recently that if residential starts this year run at a rate substantially in excess of the 1.2 million reached last year, they will encounter a "very tight mortgage money market." Mr. G. Conklin, economist of the Guardian Life Insurance Co., pointed out that "the picture is almost completely different" now from last year when easy credit conditions prevailed as a consequence of the business recession.

LOOKING AHEAD — A $600-million program to meet the arterial highway problems of the New York Metropolitan Area for the next 20 years has been announced. Divided into two main sections—toll bridges and highway connections—the plan envisages outlays of $400 million by the Port of New York Authority and the Triborough Bridge and Tunnel Authority and $200 million of Federal-state financing of the essential road links.

UNKNOWN FACTOR — It has been estimated that one pound of uranium 235 in a reactor will yield as much heat as 2.6 million pounds of coal burned in a boiler firebox. The thing that can't be estimated or measured is the economic significance and results of the development of power for industry from atomic energy.

CONSTRUCTION COSTS — After a slight decline during last summer, prices of building materials rose steadily during the final quarter of 1954, according to records of the Housing and Home Finance Agency. This agency points out that this trend could "foreshadow a greater change than anticipated" in the joint Commerce-Labor survey of construction. The latter looked for only slight increases in construction costs this year.

ZOOMING SUBURBS — Allied Stores Corp. has announced an expansion plan entailing outlays of $238 million. Seven regional shopping centers will be constructed in the next three years with the idea of providing modern "downtown" shopping facilities in heavily populated and fast-growing suburban areas.

ATOMS IN ACTION

A POWER DEMONSTRATION program has been launched by the AEC to open the way for industry to develop, fabricate, construct, and operate experimental nuclear power reactors. The aim is to encourage investment of private funds in the development of power reactors. Applicants willing to assume the risks of construction, ownership, and operation of industrial or commercial reactors have until April 1 to file applications. Proposals will be evaluated on the probable contribution of the proposed project toward attaining economic power, the cost to the AEC in terms of funds and materials, the risk to be assumed by the applicant, the competence and responsibility of the applicant, and the assurances given against abandonment of the project. As incentives, the AEC will waive certain charges for nuclear materials, will do some research and development in AEC laboratories for the applicant without charge, and will give research and development contracts to pay for information developed in the program. In another action, the AEC has released a schedule of charges it will make for materials used in atomic energy development programs, and of prices it will pay for materials produced from any private reactors.

COMMONWEALTH Associates and Jackson and Moreland have been admitted to Atomic Power Development Associates, the Dow-Detroit Edison Project. . . . The Consumers Public Power District of Columbus, Nebraska has been OK'd by the AEC for a nuclear power study. Consumers will spend $100,000 on the one-year project. . . . A Nuclear Reactor Materials Committee has been formed within the framework of the Atomic Industrial Forum. . . . Diamond Alkali will add a new radiation research laboratory to its research center to study applications of atomic energy to chemical processing operations. . . . Dr. Phillip L. Merritt, formerly assistant director for exploration in the AEC's Division of Raw Materials has joined E. J. Longyear, consulting mining engineers in Minneapolis.

THOSE HIGH-COST areas that are always talked about as the first sites for nuclear power stations have been enumerated by Lawrence Hafstad, former director of the AEC's Division of Reactor Development. The areas, as he sees them, are most of Nevada, Oregon, and adjoining portions of California and Idaho; most of South Dakota with nearby Minnesota, North Dakota, and Kansas; northern Michigan and northern Wisconsin; most of Florida and a portion of southern Georgia; and New England. But the AEC has received inquiries already about the prospects for nuclear power for Texas (even with its plentiful, cheap fuel) should its natural gas run out.

THE INSURANCE people are taking careful soundings on the influence that commercial nuclear power will have on their business. Some of the aspects they are concerned about include protection of capital investment, the peculiar demands made on equipment structures that have never been evaluated in the light of existing vessel codes and operating practices, and hazards to employees and to the general public. At the present, there simply is no actuarial data to estimate the frequency or magnitude of losses. ▲▲

REPORT FROM PARIS

FRITZ D. HIRSCHFELD
European Editor

CE exclusive

I AM NOW on my way to our headquarters in Zurich, Switzerland, with a brief stop-over in Paris. The "America" docked in Le Havre, last Thursday morning. During the past week I have been visiting daily with local and American engineers over here and at night I have been catching up on my culture.

Last Thursday, in Le Havre, I met with the director of the local Chamber of Commerce who confirmed their plans to build a new bridge across the Seine. I had heard about this in New York from Dr. Steinmann who had a hand in the planning. I am forwarding pictures and details from Zurich.

When I reached Paris on Friday, I went over to the OEEC (Organization for European Economic Cooperation) with whom I had had correspondence from the States. They have been responsible for helping to increase European productivity by sponsoring technical information from the U. S., hiring American consultants to help with local technical problems, and sending European technical missions to the U. S. Through the local offices of OEEC (in each of 18 to 20 member countries) I can have access to a lot of technical information and can make good contacts for our readers. Starting in February, OEEC will bring out a monthly publication abstracting the most interesting and significant engineering items published in European technical trade papers. This new publishing venture is for circulation among Europeans. I am on the list to receive it and will pass along pertinent data to the readers of CONSULTING ENGINEER.

Russ McBath, European Manager for Worthington operations, has been very helpful. Russ took me on a tour of the Worthington plant in LeBourget (just outside of Paris). We plan to go to Madrid together in March for two weeks to look over the Spanish Air Base work.

The trip to Spain will be fruitful. There are a number of consultants involved, and the word is the work goes way beyond air bases and includes the over-all industrial development of Spain—powerhouses, transportation facilities, harbors and docks.

Russ put his finger on a number of other interesting European developments. The story on the NATO pipeline network in France and Germany will break in about a month. American consultants were interested, but it is understood that the project has now been turned over entirely to French engineers and contractors.

There is another good story available concerning a French installation on the Brittany coast. This will be a series of turbines designed to generate power from the ebb and flow of tides. You will remember that this was started in Passemaquoddy, Maine, sometime ago, but Congress never would appropriate enough funds to finish it off. However, the French seem to think that their installation is feasible, and they are going ahead with it at a rapid pace.

I made the rounds of the local American consultants—there are approximately six groups working on American air bases in France. Their comments on the work and working conditions are interesting. The majority of the present consultants—Cutting Associates (Cleveland); Ammann & Whitney (New York); Lublin Associates (Norfolk, Va.); Frank Grad (Newark, N.J.) in a joint venture with Seelye, Stevenson, Value and Knecht (New York); and Greer & Associates—established their offices in Paris in 1952, to facilitate obtaining and expediting these military airbase contracts. While working for Uncle Sam in Europe is no longer the lucrative cost-plus proposition of the early postwar years (contracts are now let on a straight fee basis and competition is very keen), it still pays well.

All these firms are busy and currently seem to be getting along fine. They have successfully (to varying degrees) reconciled American and French engineering construction methods. Since many of the key American personnel have been in postwar Europe for quite some time, either with the military or with engineering firms, they have learned to accept and live with the local conditions.

Although friendly, everyone tends to be more close-mouthed about his operations and activities. Social or business contact between the different engineering groups appears to be practically non-existent. This attitude seems to reflect a European influence although competition and security reasons were mentioned. Contact with the U.S. is primarily through engineering magazines and through the partners, who, of course, travel extensively. Most of the men, however, prefer to spend their leave time in Europe.

For the casual visitor to Paris, it is a real problem

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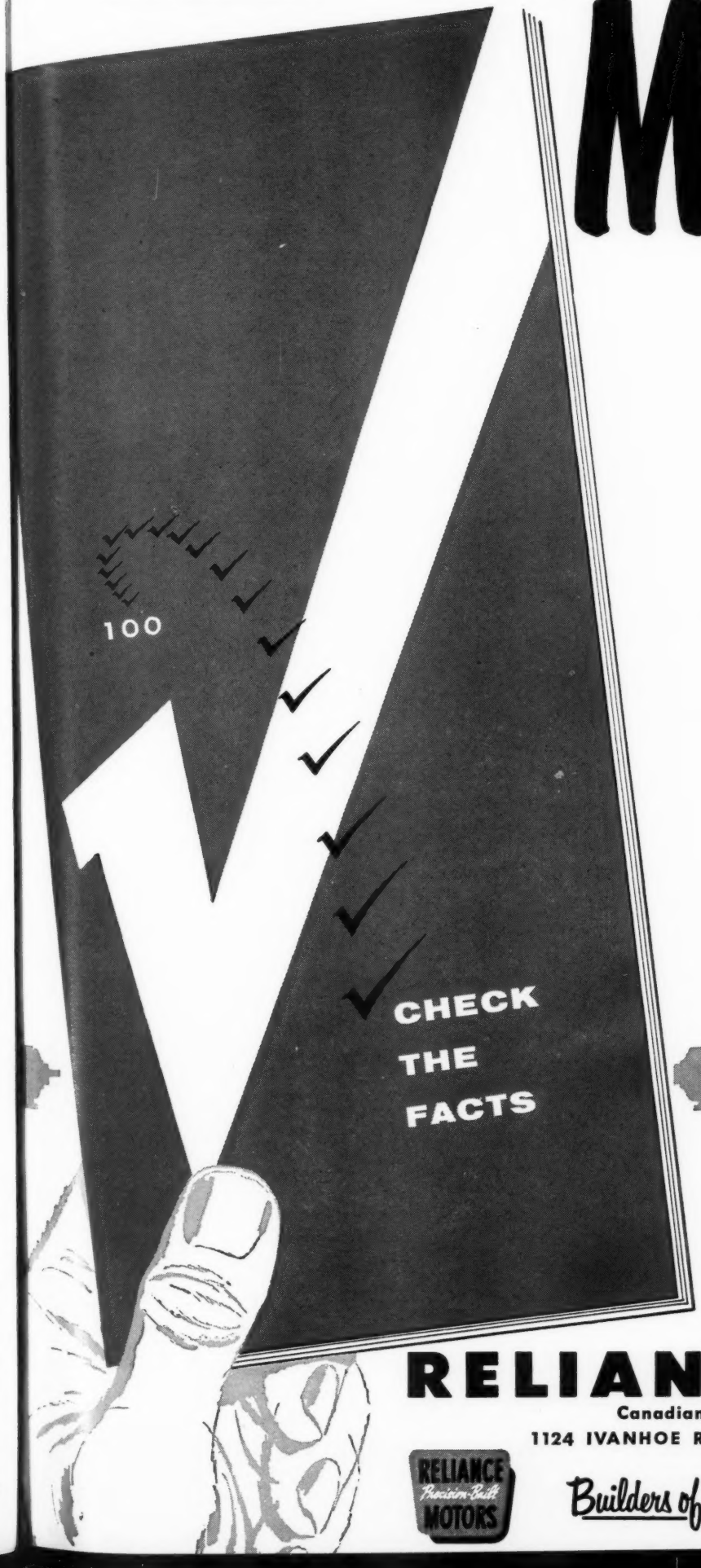

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Ronald B. Peterson

Director, Industrial Location Service

to try to locate the American consultants. They are not listed in the phone book, and to add to the confusion, the name of a French associate, rather than the American name, appears on the door of the office or building (this is supposed to be for political reasons). All this inadvertently helps create an air of secrecy and seclusion.

The big questions in Paris are: Where do we American consultants go from here? What happens when the military construction is finished? What are the chances for doing private work?

The immediate reaction after talking with four of our American consulting engineering firms who have offices in the Paris area is that the future engineering prospects for American consultants in France are not promising.

On the face of it, it looks this way. The military airbase construction work is rapidly drawing to a close. Unofficial word from our JCA (the Joint Construction Agency is the government body responsible for military construction in most of the European theater) headquarters in Boulogne (a suburb of Paris) has it that the program in France is expected to terminate very shortly. While there has been speculation that programs may start in Italy and possibly Denmark, nothing definite has been decided to date. The Spanish airbases were previously committed in the U.S. under separate contracts.

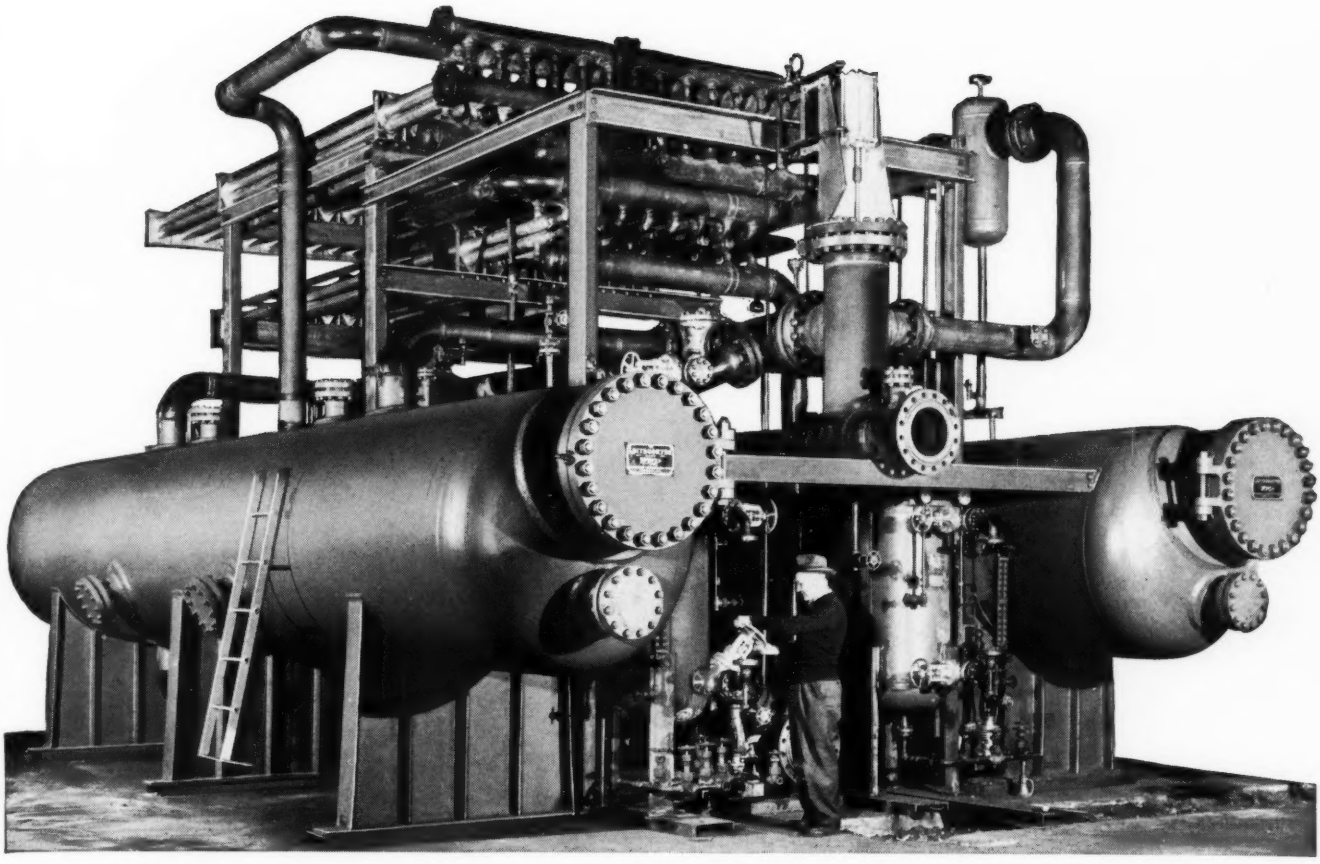
One obvious answer is to pack up and go home when the present commitments end. Another possibility is to bid on the operations and maintenance phases that will probably follow the completion of the bases. An outside chance may lie with future airbase construction in other countries. Private work is almost unanimously discounted because of currency difficulties and the obvious objections that would be raised by local French engineering firms.

However, there are other forces at work that may change the picture. The French economy is starting to boom. Increased industrial output is creating strong and deep pressures. For example, more cars on the roads call for better highways and new bridges. Similar pressures are being exerted in other fields, too, and undoubtedly will be reflected in growing demands for modernization of antiquated sewage and water supply systems, improved warehousing and distribution methods, modernized industrial plants, large housing projects, and better communications.

And while no one today can foresee how the riddle of French politics and social problems will be resolved in the future, if the internal economic pressures are strong enough, answers will certainly have to be found.

I am leaving for Zurich tomorrow, riding on the rubber-tired train. I have received a very cordial reception, having been entertained by local as well as American engineers here in Paris.

My next report will be from Zurich. ▲▲



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ENGINEERS HAVE PLANNED THE ST. LAWRENCE POWER AND SEAWAY PROJECT FOR OVER 50 YEARS. SHOWN IN THIS VIEW IS THE SITE OF THE LONG SAULT SPILLWAY DAM AT BARNHARDT ISLAND.

The St. Lawrence Seaway

CE exclusive

An Engineered Shift in The Nation's Economy

JOHN S. G. SHOTWELL, Partner
Nebolsine, Henderson & Shotwell

THERE ARE only four natural trade routes through the mountains that ring the rich interior of North America, cutting it off from direct access to the ocean and world trade. These are the St. Lawrence-Great Lakes route, the Hudson-Mohawk route, the Susquehanna-Lackawanna-Potomac-Cumberland Gap route, and the Mississippi River.

Of the four routes, the St. Lawrence River is the only one that can be developed into a seaway and at the same time provide over 10 million kilowatts to a region badly in need of new sources of power.

Rapids and shallow-draft canals in the St. Lawrence and in the connecting rivers of the Great Lakes now block the passage of large ships from tidewater to the interior. Canada has begun construction of new facilities in these sections, however, and it expects to see the first 800-ft vessel pass through before the close of the 1958 season.

Canadian Leadership

The Canadians have underwritten more than 83.4 percent of the total cost and are waiting to see the character and extent of American participation in the cooperative effort ahead. Canada is prepared, willing, and able to complete the task itself.

Announcement of its decision to complete the

THE ST. LAWRENCE IS ONE OF FOUR NATURAL TRADE ROUTES INTO THE INTERIOR OF NORTH AMERICA.

Seaway was made in 1951. It came at a time when the opening of new iron ore deposits and the growing demand for export of power to keep American factories running had caused Canadians to realize that times have changed—that Canada now holds the key to the future of American heavy industry and commerce.

The St. Lawrence Seaway development might seem at first sight to run counter to the movement of continental economic unity. A deeper study, however, will show that this is not true. It will not lessen the American economic structure to have Cleveland, Chicago, Detroit, and Duluth develop as ocean ports. In fact, it will strengthen the country as a whole by furnishing these cities and the lands behind them with a vastly increased stimulus for economic growth.

Many of the facilities required for the Seaway are already in existence. The New Welland Canal, for instance, provides a waterway between Lake Ontario and Lake Erie. Thirty miles long, it incorporates eight locks, each 860-ft long, 80-ft wide, and with 30-ft of water over the sills. Although Canadian engineers saved several million dollars during construction by dredging the canal to a depth of only 25 feet, Department of Transport is now deepening these reaches to the designed 27 feet.

Another section of the Seaway program has been constructed by private interests. The Beauharnois Power Co., now the Quebec Hydro-Electric Commission, built a 1,125,000-kw hydro-electric plant at Beauharnois, Quebec, some 50 miles east of the U. S.-Canadian boundary on the St. Lawrence. The engineers designed the power-intake canal so that it could be used as part of the Seaway.

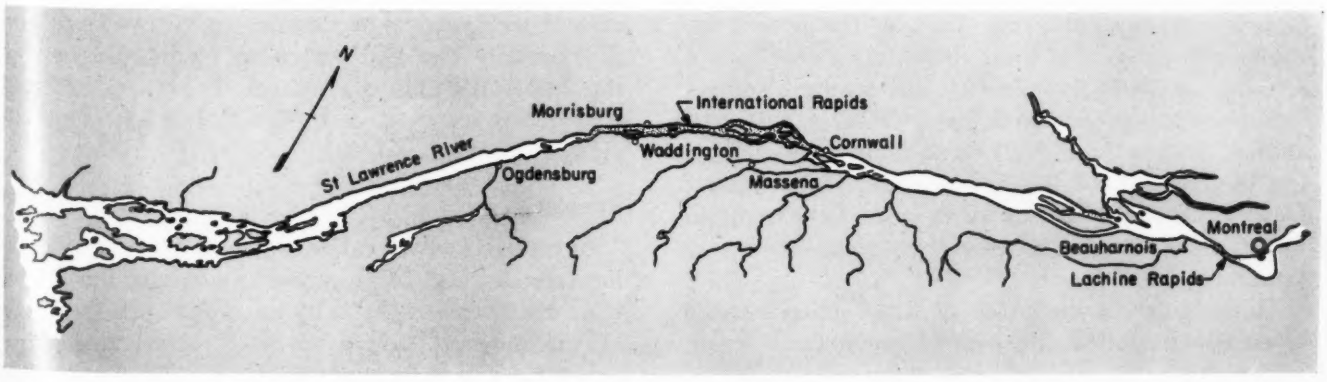
Still another component of the Seaway already constructed are the four American locks and one Canadian lock at Sault Ste. Marie. The larger locks are capable of handling 860-ft ships with an 80-ft beam. The reaches on each side now have minimum depths of only 25 feet, but Canada already is dredging its canal to a 27-ft minimum depth.

The Lower St. Lawrence River, from Montreal to the ocean, has a 35-ft channel permitting 32-ft shipping even under the most adverse conditions.

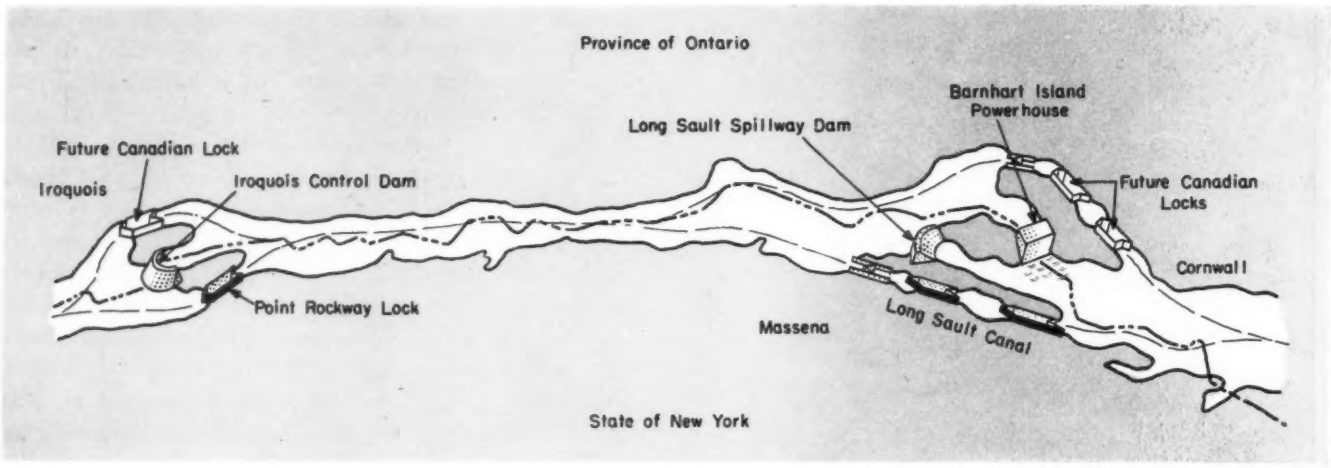
New Construction

Completion of the Seaway requires only the construction of twin locks and a connecting channel at Beauharnois; the replacement of the small, shallow-draft, Canadian canals at Lachine, Cornwall, and Iroquois by new canals having locks 860-ft wide and 30-ft deep; plus the dredging of 27-ft channels across Lakes St. Louis and St. Francis and through the St. Clair River at Detroit.

The Lachine Section consists of a 14-mile canal with two locks and channels across Lake St. Louis. The designs call for a dike paralleling the south shore of the river, extending from just below the Victoria Bridge to immediately below the Lachine Rapids. There the dike runs up onto the south shore



COMPLETION OF THE SEAWAY INCLUDES NEW TWIN LOCKS AND A CONNECTING CHANNEL AT BEAUHARNOIS; REPLACEMENT OF THE CANALS AT LACHINE, CORNWALL, AND IROQUOIS; AND DREDGING BETWEEN CORNWALL AND LACHINE.



THE ST. LAWRENCE POWER PROJECT CALLS FOR A RETAINING DAM AND A POWER DAM WITH TWIN POWER HOUSES AT BARNHARDT ISLAND AND AN UPPER CONTROL DAM AT IROQUOIS. LOCKS WILL BE BUILT TO BY-PASS THE DAMS.

and the canal, with one lock, cuts across the land to Lake St. Louis. This section is being constructed solely by The St. Lawrence Seaway Authority, created in 1951 by act of the Canadian Parliament. This work has already started and is expected to be completed in 1958 at a cost of under $100 million.

The Beauharnois, or Soulanges Section, requires only the dredging of the power canal to a depth of 27 feet and construction of twin locks and a short connecting channel to by-pass the power plant. This is expected to cost less than $15 million and be ready for operation early in 1958. Quebec Hydro is participating in cleaning out the intake canal, since the deeper channel will increase the potential capacity of its plant from 1,250,000 kw to 1,500,000 kw.

The International Rapids Section extends from near the U.S.-Canadian boundary's junction with the St. Lawrence River, a few miles east of Massena, N.Y. to the Galops Rapids seven miles east of Ogdensburg. A drop of over 80 feet in this section represents a source of two million kilowatts.

Joint Construction

The plans call for joint construction by the New York State Power Authority and the Ontario Hydro-Electric Commission of hydro-electric works capable of producing 1,880,000 kw. Cost of the hydro development will be $600 million. Navigational canals around the dams and clearing out of the channels between Ogdensburg and Lake Ontario will cost another $105 million. The United States is constructing this portion of the Seaway under the Wiley-Donaldo Act, but Canada has retained the right to maintain its present canals and to enlarge them any time it sees fit.

The engineering features of this section consist of an upper control dam near Iroquois, Ont., which will control the level of Lake Ontario; a retaining dam, spillway, and a main dam with twin powerhouses between Massena, N.Y. and Cornwall, Ont.; dikes along the banks to retain the pool level; enlargement of some reaches of the channel to reduce the current velocity; and construction of side canals past the two sets of dams. The project will inundate considerable land, including 14,000 acres of farm land, and will mean relocating railroads, highways, several towns, and several thousand people.

Costs

The New Welland Canal involved an expenditure of $132 million during the twenty years it took to complete. Although Canada charged no tolls for its use, it has amortized the capital costs through government funding as if it has been a revenue producer. Now Canada must spend an additional $2 million for deepening it. The St. Lawrence Seaway Authority will spend another $200 million in constructing the Lachine Section, the locks at Beauharnois, and in dredging the channels across Lake St. Louis and Lake St. Francis.

The total cost of the Seaway to Canada, figuring $260 million for construction and interest charges for the New Welland Canal and $40 million for miscellaneous navigational works, will be $500 million. Adding the $105 million that the United States will spend in the International Rapids Section, the total cost of navigational works on the Seaway will be $605 million. This figure does not include the cost of the locks at Sault Ste. Marie. The St. Lawrence Power Project will cost New York and Ontario another $600 million.

Revenues

Revenues from the Seaway are difficult to estimate accurately. The ultimate capacity of the canals is an estimate arrived at by multiplying the tonnage of the average largest class of vessel using the canal by the maximum number of passages that can be made through the canal.

The present capacity and utilization of the St.

Lawrence-Great Lakes trade route is compared to the ultimate traffic through the Seaway in Figs. 1 and 2. Based upon the best Canadian estimates, it seems likely that the Seaway will ultimately handle over 200 million tons per year, and that Great Lakes shipping will move another 100 million tons.

A more realistic estimate for calculating revenues for the years immediately following completion of the Seaway would be 20 million tons per year of Labrador iron ore passing up the river, 15 million tons of grain passing down, and 15 million tons of general cargo passing up and down the river, for a total of 50 million tons per year.

Canada and the United States have agreed not to charge tolls of more than $1.25 per ton for the entire trip from tidewater to the Upper Lakes. Assuming that the maximum toll charge is made, the Seaway would then collect $62.5 million annually. If it costs $12.5 million per year for operations and maintenance, $50 million will be left to pay off the capital costs. In addition, the hydro development should return over $100 million per year.

If, on the other hand, the Seaway handles 30 million tons of iron ore, 20 million tons of grain and 30 million tons of general cargo (as envisioned by Chicago, Toronto, Detroit, and lower lake port shippers), the total would be over 100 million tons a year. This would bring a revenue of $125 million from shipping, or a gross revenue of $225 million.

The Seaway is expected to pay for itself within ten years. After that, the revenues will tend to reduce taxes — Canada definitely figures on this. In addition, it should save the people of this country over $1 billion per year in freight costs.

Arguments Pro and Con

Many of the opponents of the Seaway point to the seasonal character of navigation on the St. Lawrence. Although it is true that, for the present, the St. Lawrence will be closed to navigation for the winter months, the opponents have overlooked two very important factors.

The first factor is that engineers can overcome the winter shut-down. For instance, the Corps of Engineers has changed conditions of navigation upon the Hudson so that now Albany is open the year around instead of being the eight-month port it was 30 years ago. The railroads and Great Lakes shippers have made similar changes on the Lakes. Car-ferries and other vessels now ply regular scheduled runs throughout the winter across Lake Michigan.

The feasibility of constructing navigational works on the St. Lawrence to keep it open throughout the year is already under study.

The second factor is the seasonal character of the traffic. The bulk of the freight to and from the Midwest and Northwest consists of grains, iron ore, coal, and automotive materials — all products having peak freight demands during the months of April to December and much smaller demands during the winter. The proper development of Seaway traffic may even tend to broaden the bases of several of these demands.

A factor that many proponents overlook is the practical certainty that the great bulk of cargoes emanating from or bound to Great Lakes ports will require transshipment in or near the St. Lawrence. The Seaway will handle "lakers" of 27,000 tons and some ocean craft of 17,000 tons, but it is not expected that many ocean-going ships over 10,000 tons will make the run to the Upper Lakes. The extra two or three weeks that such a run would require over the normal trans-Atlantic run makes such operations uneconomical.

Most shippers expect that the ocean-lake run will be confined to vessels under 10,000 tons and that the bulk of the traffic will still be carried by lakers. These huge floating boxes, specially designed to

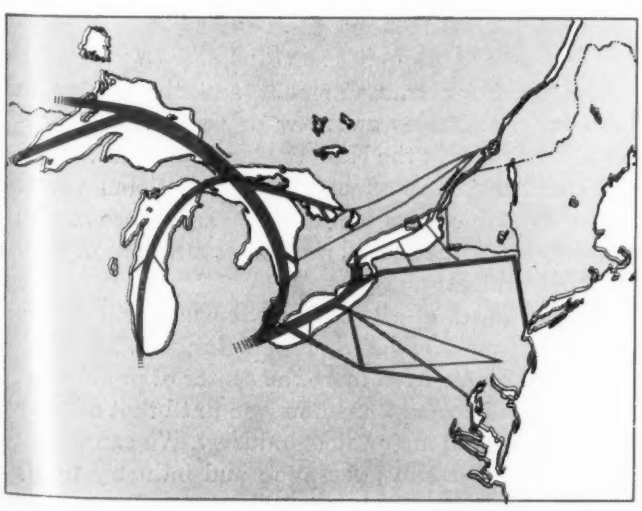


FIG. 1 — APPROXIMATE SHIPPING ON THE GREAT LAKES AND THE ST. LAWRENCE RIVER DURING 1953.

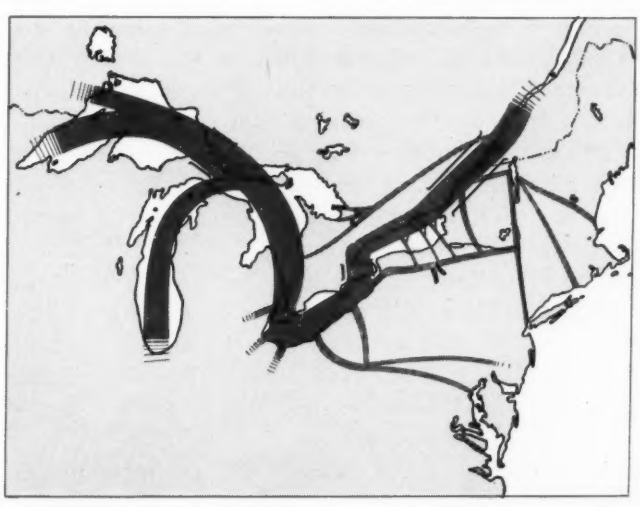


FIG. 2 — ESTIMATED TRAFFIC ON THE ST. LAWRENCE AND THE LAKES UPON COMPLETION OF THE SEAWAY.

carry the maximum through canals and rivers, cannot go to sea safely and must therefore transship their cargoes to other vessels at ocean ports.

A further disadvantage, often overlooked, is that even if the Seaway could carry the larger ocean liners, every bridge above Montreal would require rebuilding to permit them to pass. Ocean liners and large freighters need a 150-ft vertical clearance — not the mere 85 feet now considered ample for bridges and other channel crossings. Even with the use of lakers, the ultimate development of Seaway traffic will cause such delays in highway and rail traffic over lift and swing bridges that it will be necessary to replace all of these bridges with high-level fixed bridges.

Great Lakes Shipping

An examination of shipping data on the St. Lawrence-Great Lakes trade route indicates that most of the largest lakers do not enter Lake Erie and very few pass through the Welland Canal. Because so few ports on the lower lakes can handle the deep-draft vessels, the expenses incurred in using them make such an operation uneconomical. This is a strong argument in favor of building additional facilities on the lower lakes as a part of the total Seaway scheme.

At present, grain ships and ore boats leave the head of the lakes loaded to capacity, sail to ports on Lakes Michigan, Huron, and Erie, and then return empty. A few sail through to Montreal and a very few are ocean vessels that have taken on grain for Europe. With the completion of the Seaway, this traffic will continue with more of the vessels going on to Montreal and returning loaded with Labrador iron ore for the Midwest mills, or carrying pulp wood from Anticosti or paper from the lower St. Lawrence mills.

Future Traffic

This does not indicate a miraculous jump in traffic. However, it does mean that freight traffic on the Great Lakes will double within a few years. The increased lake traffic will be accompanied, to a large extent, by a decrease in long-haul land freight running east and west, and by an increase in land and water freight running north and south. The enlarged lake ports will service an area running as far south as Cincinnati and St. Louis.

The reduction of truck freight from the Midwest to the East Coast will reduce the demands for more highways paralleling those now in service. It will therefore be necessary to restudy Midwest traffic flow, with land-borne freight mainly routed north-south instead of east-west.

The opening of the Seaway will permit shippers to send goods cheaply between the Upper Lakes and tidewater. The saving on wheat to an Atlantic Coast port will be over ten cents per bushel or $3.20 per ton. Such a saving would mean $100 million in the pockets of Canadians and Americans yearly. Reduction in price of export grain also would mean the sale of many millions of extra bushels.

The shipment of goods from Northern Europe or the Eastern Seaboard by ship to Chicago and thence by barge down the Mississippi will reduce the costs of many imported articles. Similar shipments to Cleveland can be expected with transshipment by rail to western Pennsylvania and to the Ohio River. The return cargoes are just as important because many rates are now based on a one-way pay load. Automobiles can be shipped to New York on the return trip at savings of over $50 per car, and to the Southeast at saving of more than $200 per car.

Long-Haul Water Transportation

Consulting engineers and industrial executives must be alert to the advantages of developing long-haul water transportation with new methods of loading, transshipment, and delivery. As an example, sea trains and trailer ships offer a means of shipping perishables and easily damaged goods to their final destination with only one packing and one unloading. Such a combination is now being worked out between McLean Trailers and the New Haven R.R. for shipping goods to Northern Atlantic ports. Loaded trailers are run on board special ships at Savannah, Charleston, or Wilmington, N.C., and are sailed to a northern port. They are then unloaded and hitched to tractors or loaded onto piggy-back rail cars for shipment to their final destination.

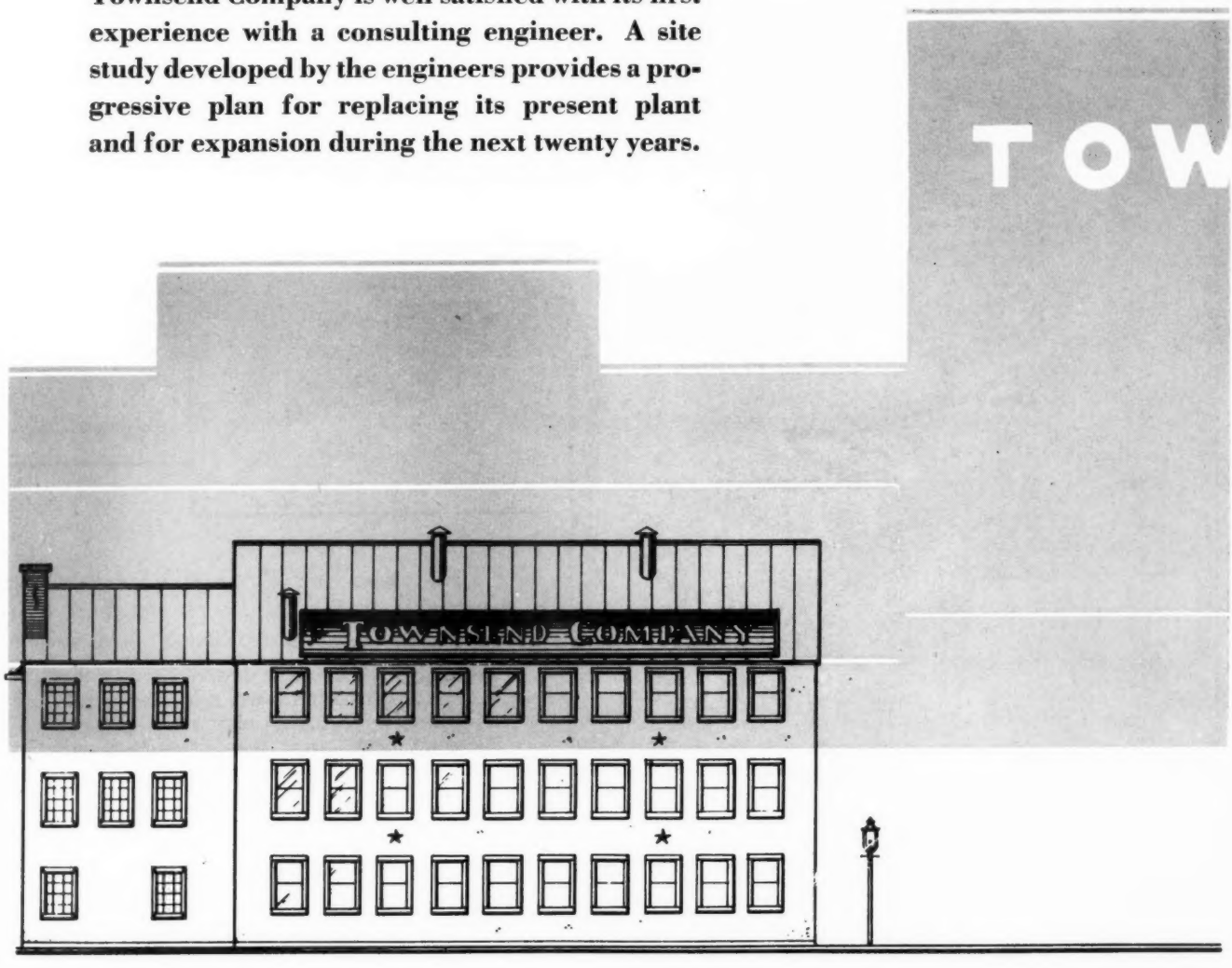
A similar scheme might be worked out for shipping perishables from the South to the Midwest. Perishables could be trailer-shipped from Georgia to Providence, carried piggy-back by the New Haven to Ogdensburg, and then loaded on lakers for Detroit and Chicago. From these ports they would be shipped by rail to distributing points and then trucked to their destinations. The trailers could be returned loaded with products from the Midwest.

Economic Effects

The need for transshipment and the saving in time for perishables and raw or semi-finished materials will benefit the New England railroads. When combined with the effects of the additional power made available through the St. Lawrence hydro development, this should mean a resurgence of New England industry.

The over-all effect of the Seaway will be to strengthen the Midwest and New England. The Midwest will become even more the center of production, with dependence on Canadian iron until that country develops its own major steel industry. We can expect to see the Canadian population and industry treble in twenty years, however, with more and more use of its own raw materials and continental integration in fabricating the finished products. ▲▲

Townsend Company is well satisfied with its first experience with a consulting engineer. A site study developed by the engineers provides a progressive plan for replacing its present plant and for expansion during the next twenty years.



CP exclusive

Engineering a Site Study

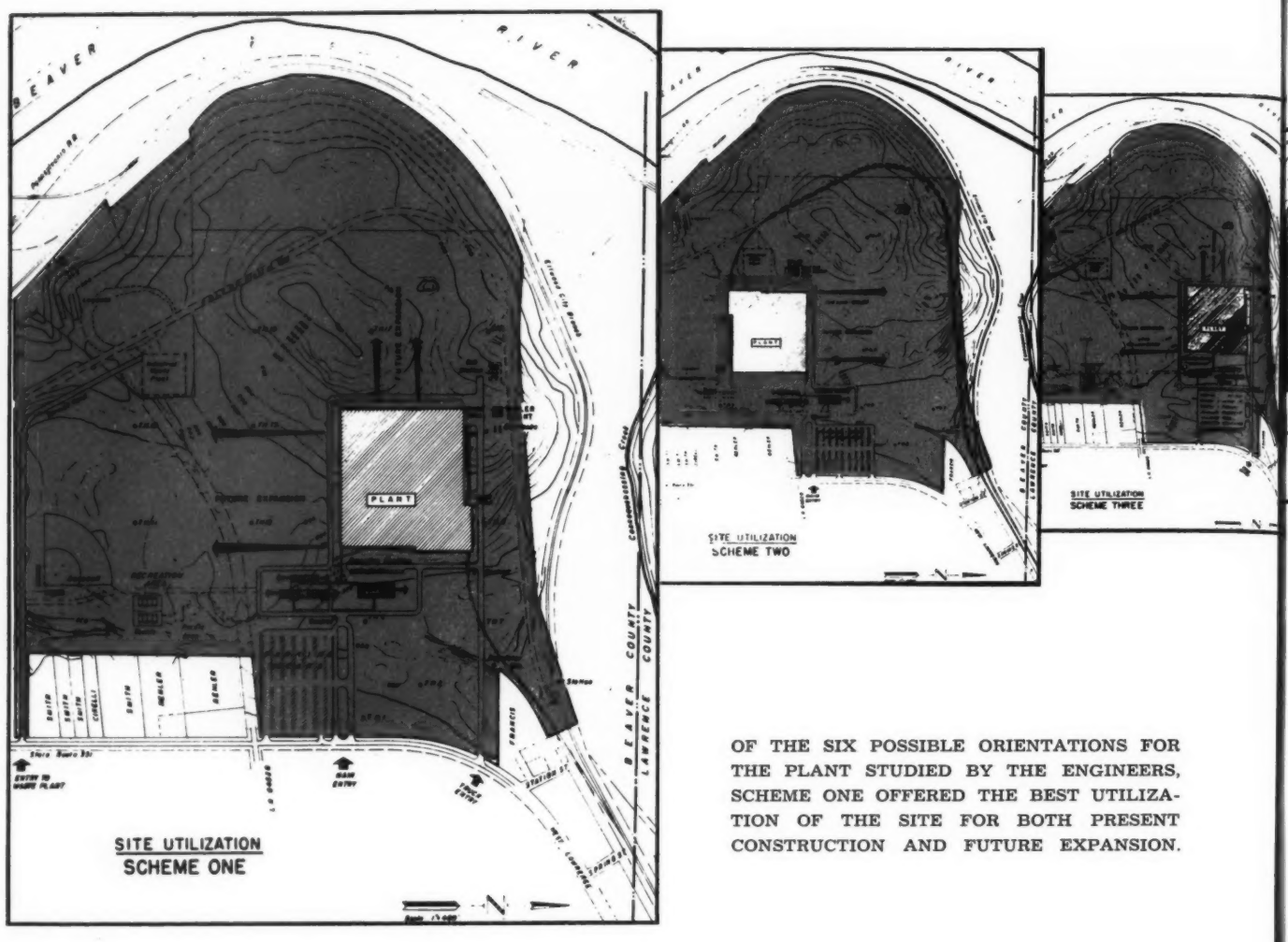
For Twenty Years of Plant Growth

THE TOWNSEND Company, a manufacturer of industrial fasteners, wanted to develop a program for the progressive replacement of its existing plant in New Brighton, Pa., and the construction of modern facilities at nearby Ellwood City. The company had not used the services of a consulting engineer in previous plant expansions, and they were reluctant (because of cost) and hesitant (because of lack of experience) to approach the consultant.

Their decision to use a consultant, however, came about through a regional planning report of Beaver County made in 1944 by the consulting firm of Michael Baker Jr., Inc. This report was used by Townsend in choosing their actual site and, in turn, led the company to consider Baker's organization.

Michael Baker and his associate in architecture, Joseph Bontempo, introduced themselves to the Townsend management. They explained that their procedure would be to determine the most functional, economical, and attractive use of the available plant site by investigating all possible plant layouts. Their recommendations could then be used by Townsend in making a choice between alternates.

The plan would be developed to provide a progressive and orderly expansion of the plant by phases, each phase proceeding independently and with a minimum of interference with previous work. The study could then evolve a specific program of plan-



OF THE SIX POSSIBLE ORIENTATIONS FOR THE PLANT STUDIED BY THE ENGINEERS, SCHEME ONE OFFERED THE BEST UTILIZATION OF THE SITE FOR BOTH PRESENT CONSTRUCTION AND FUTURE EXPANSION.

ning, preliminary costs, and construction. Townsend was impressed with Baker's proposal and with the ability and past experience of his engineers.

First Step

As a first step in developing a master plan to show the current and projected plant needs of the Townsend Company for a period of twenty years, four major elements were considered:

1. *Physical Properties of the Site.* The size, shape, orientation, topography, stability of the subsurface, soil analysis, and the effects of rain, wind, and snow.
2. *Services to the Plant and Site.* Existing and proposed utilities into and out of the site; transportation by rail, truck, and car; and the necessary communication facilities.
3. *Employee Facilities.* Parking areas, minimum walking distances, public transportation, and recreational areas.
4. *Cost Estimates.* Preliminary costs of each phase of the master plan in addition to an estimate of the total project cost were developed.

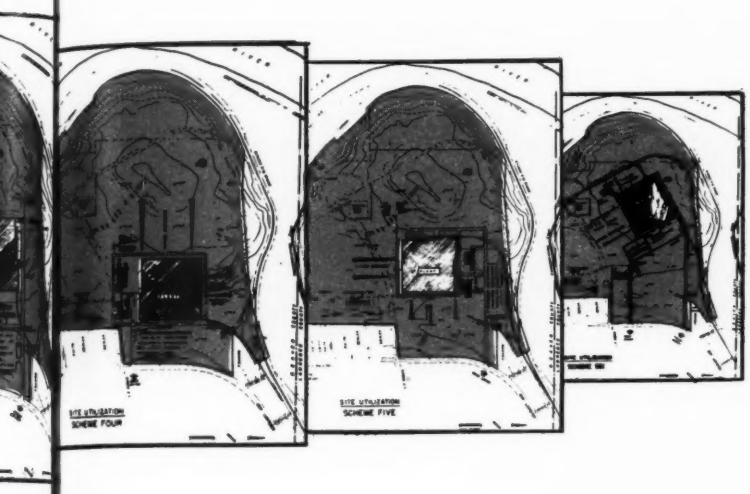
The physical properties of the site were readily determined from surveys, aerial photographs, core borings, and a study of existing climatological data. All actual records of the core borings and profiles were included in the appendix of the report.

Having broken down the total areas of buildings, roads, parking, boiler plant, and other space occupying facilities — and allowing space for the expected future plant expansion over 20 years — the next question was the orientation of the plant on the site. Keeping in mind stated limitations, four orientation schemes were worked out diagrammatically with the advantages and disadvantages of each listed.

Utilities

Before making detailed layouts of the plant, it was necessary to locate and size existing utilities. The location of these utilities would determine the final layout and location of the plant on the basis of economy. The utility companies were also contacted to learn of their future plans for expansion as it would concern the new Townsend Plant.

Based on the four previously worked out plant orientation schemes, and taking into further account the existing utilities, six detailed site utilization schemes were laid out diagrammatically, again with the advantages and disadvantages of each carefully enumerated. A further comparison of the



schemes was made on a cost basis. After studying each proposed layout, the scheme one shown above was decided upon as being the layout that most clearly met the requirements of function, best utilized the site for future expansion, and was most attractive. It was mutually decided to further investigate the potential in Scheme One.

The basic development program called for replacement facilities to be constructed in two phases. The first phase would be a building large enough to house approximately 30 percent of the final plant production. The second phase would provide enough additional floor area to replace all of Townsend's existing facilities.

Based on the growth of Townsend under its present administration as well as such factors as the nearness of the new plant to its source of raw materials and transportation facilities, it was estimated that the plant would double in size in the next 20 years. One of the main considerations of the site utilization, therefore, was the provision of adequate space for a third expansion.

First Phase

The first phase of construction included 81,000 sq ft of plant space. It also called for the preparation of the site by excavation and leveling, construction of access roads and temporary parking areas, plus the installation of an industrial waste plant, boiler plant, and necessary utility lines. Since the excavation work involved heavy construction equipment, it was decided to complete all earthmoving in this first phase while the heavy equipment was on the site.

It was an important step to confirm the utility commitments—the letters were included in the Site Study — since there have been known incidents where local interests, in their enthusiasm to have a new company locate in their area, have made many promises that later could not, or would not, be fulfilled. Baker's engineers made certain that the responsibility and financial obligations which each group was prepared to undertake were clearly defined so that the planning could proceed without danger of questionable commitments falling through.

Preliminary Costs

The cost of the first construction phase was estimated on preliminary planning and without benefit of design drawings. Undoubtedly, economies could be effected in the final design of the plant by means of comparative cost analyses of structural types and materials. However, the report would serve as a basis for estimating the final cost of the project and for evaluating bids on the construction.

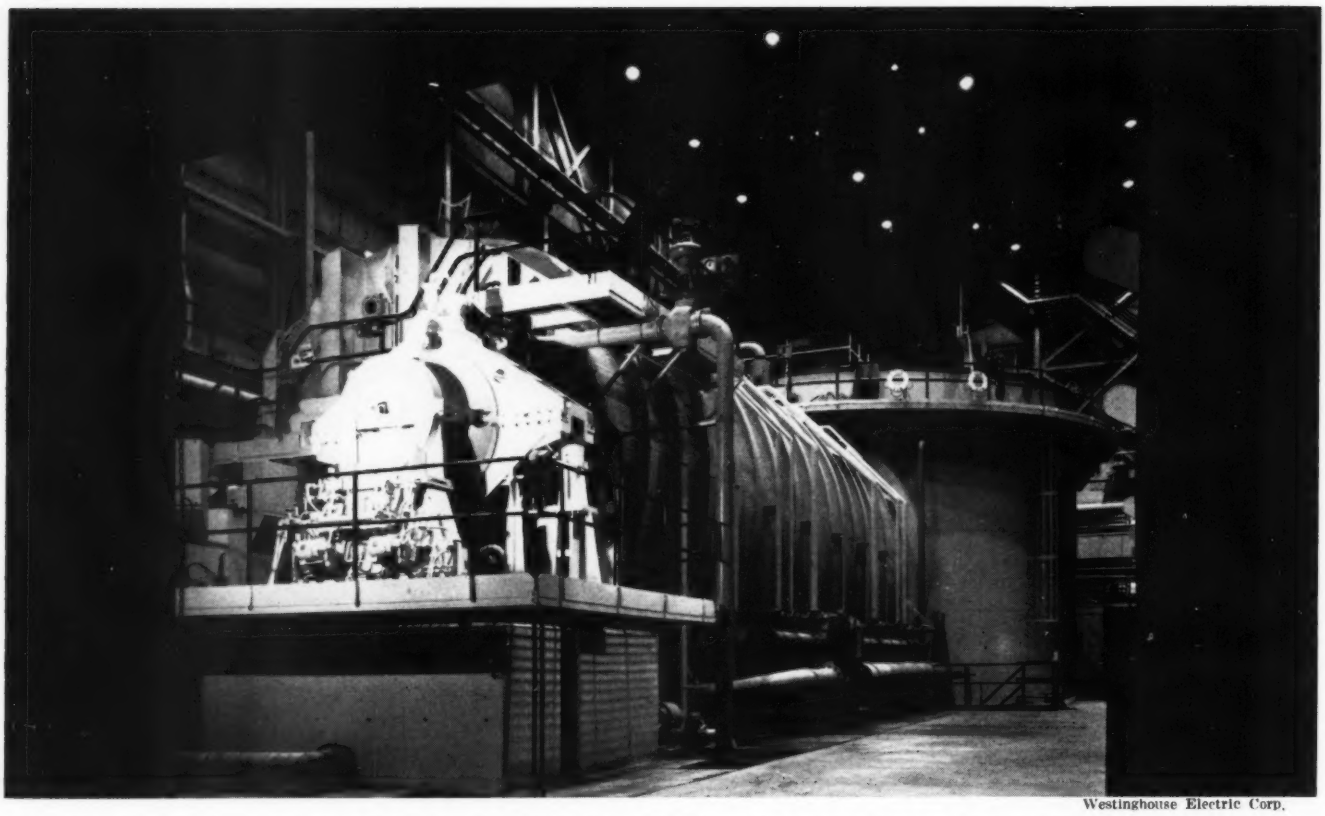
The preliminary cost estimate for the second construction phase was similarly divided into sections (site work, railroad, landscaping and recreation area, exterior electrical, telephone installation, etc.) in the same way that these items would be considered in letting separate contracts.

Recommendations

Final recommendations included acquiring two small parcels of land for the realization of the overall planning outlined in the report; using a coal-fired boiler system with automatic stokers and ash handling equipment; a separate building to be used for employee lockers and showers; a further study to be made on materials handling equipment; placing orders for critical and special equipment and materials. Justification for the recommendation for a separate building for lockers and showers as well as for the heating and ventilating systems were included in the appendix of the study.

This report gave the Townsend management a step-by-step program for developing their new facilities. At the same time, they could review the thinking that led to the recommendation of the final plant layout scheme. The preliminary cost estimates gave them a picture of the financial burden to be expected. Commitments for the utility services paved the way for a mutually friendly relationship with these interests. The report was also useful in anticipating future problems that would undoubtedly arise. As stated in the report, it could serve as the basis from which planning adjustments could be made, and by keeping it up-to-date in the matter of cost and changing production requirements, it would be of continuing value.

The Townsend management was well satisfied that their experience with a consulting engineer had resulted in their getting the best possible plant facilities for their money. They also knew that almost every possible situation had been explored and taken into account so that the program would proceed smoothly on the calculated timetable and within the cost figures. ▲▲



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Mr. Pickard had been with the AEC for six years before entering private practice. He organized and administered the AEC's Industrial Participation Program under which dozens of firms are studying the technology and economics of power reactors. He also worked on evaluations of reactor types, was technical advisor in drafting amendments to the Atomic Energy Act, and worked on AEC Committees concerned with international and electric utility problems. He also worked at Johns Hopkins Physics Laboratory, Douglas Aircraft, and General Electric. He has an E.E. degree from M.I.T.

NUCLEAR ENERGY will bring great impact to bear on the practice of consulting engineers—far greater than has been felt yet. To adequately appraise this impact, several factors unique to nuclear energy deserve attention.

Perhaps the fundamental, unique aspect of work in this field stems from the peculiar characteristics of nuclear radiation itself. Many of the basic engineering problems relate to materials behavior and environmental hazards as affected by radioactivity. Another unique factor in nuclear energy lies in the fact that it was born as a war baby, costing many billions of dollars to conceive and deliver. Because the initial work was directed at weapons development under war-time pressures, the nuclear energy business has enjoyed a rare disregard for value returned per dollar spent.

Blue-sky scientists have been in the driver's seat since the beginnings of the nuclear energy business. This is logical and has been necessary from the nature of the beginnings. What will be needed from here on are the kinds of industrial management teams (with their retinue of engineers, draftsmen, and technicians) that have the demonstrated ability

to do the sort of work required to reduce nuclear energy to commercial practicality. (An effort is already being made to call upon the type of industrial management teams that have been eminently successful in similar development of other commercial fields. The Army has just awarded a contract for a packaged nuclear reactor, specifying requirements in terms of end use rather than by specifying vague objectives for learned investigation.)

The "Out's" and the "In's"

Another problem in this business is that just a few industrial companies have been the hand-picked instruments of the government in developing nuclear energy to this date. The "out's" will have a terribly hard uphill fight simply because the "in's" already have lots of background learned at government expense. (And it is now the announced policy of the AEC to call a halt to educating industry with government dollars.) For those who do not yet have their head under the tent, including consulting engineers, it will be difficult to make a significant entry into this rugged business. It takes a lot of dollars to get started in nuclear energy. Machines are costly. Radiation cannot be handled cheaply. No one can get started in a bicycle shop or in a garage.

Another and perhaps the most critical peculiarity of the nuclear energy business is the matter of secrecy. Much significant work has been declassified or is unclassified. However, some very important engineering information remains under the cloak of secrecy, making it difficult (not impossible) for anyone on the outside to catch up.

Forbidding as these conditions appear to be, it is nonetheless true that nuclear energy will reshape most of the technology that is the bread and butter of a good many consulting engineers. To survive, they will have to realign their thinking. The facts seem to show that outstandingly important for the next several years will be the generation of electric power and the propulsion of ships by nuclear energy. Even these two applications may prove minor over the long haul, because the sterilization of foods and the use of isotopes as catalysts hold great potential.

Fuel costs represent no more than 15 percent of the utility industry's charge for delivered electric energy. With but that 15 percent upon which nuclear energy could work its advantages, it is likely that greater measures of success can be met ultimately in other industries. The chemical and food industries are not subject to the same close scrutiny of regulatory bodies as utilities. The chemical industries are characteristicly large operations with phenomenal growth not being unusual. Though the use of nuclear energy in the chemical and food industries appears to be a long-range proposition, the stakes do appear higher.

Nevertheless, it looks as though power and propulsion will be the consulting engineer's realms to be re-shaped by nuclear energy within the span of our careers. The most immediate promise for economical nuclear power (within 5 to 10 years) depends on the solid-fuel, water-moderated, water-cooled reactor. The liquid-fueled reactor holds greatest promise over the long range. But engineers now know what water is and how to handle it — in contrast to their lack of confidence in handling aqueous and molten uranium solutions.

Unless the solid-fuel, water-moderated, water-cooled reactor can be developed to the point where it utilizes the potential energy of its fuel at least ten times more efficiently than it does now, the liquid-fueled reactor will continue to threaten. Once the technical problems of handling the molten metals are licked, the contest between reactors will be decided by their efficiencies of fuels utilization.

By 1965, nuclear power stations will probably account for between 1 and 10 percent of the country's total installed generating capacity. By 1970, just five years thereafter, the country's installed capacity in nuclear stations may be between 3 and 20 percent of the total. (These figures include system capacities installed in pre-atomic days. They assume that, as a minimum, one out of every three new stations built in 1970 will be nuclear powered.)

Power generation, of course, is not the only field served by consulting engineers. But of the industrial firms known to me to be thinking of diversifying their lines of business, perhaps half are thinking in terms of nuclear energy. Any consultant serving firms that choose the nuclear road to diversification will find themselves knee deep in nuclear problems.

Two Routes

The consulting engineer may find his client traveling the nuclear road by one of two routes. One route calls upon the atom to serve as a tool to improve the production of goods that the client's company has long made. The other path is that of creating a proprietary interest in the nuclear energy business through the development of equipment, devices, and techniques peculiar to atomic energy.

The biggest problem the consulting engineer can expect is finding too few people around who have had experience with nuclear energy, and who also have had experience in general industry. Consulting engineers know the industry side of things. But they will have to develop a feel for the atom. Some have it, but there are far too few of these. There is no great backlog of people with nuclear energy experience. Nuclear engineers cannot be hired on the open market as easily as electrical, chemical, or mechanical engineers.

Nuclear energy is ripe for plucking. The problem is guidance. The need for consulting engineering services with atomic adjuncts will grow in proportion to the speed and extent with which nuclear energy appears on the everyday scene. ▲▲

THE HIGH-TENSILE BOLTS ARE TIGHTENED BY USING AN IMPACT WRENCH ON THE NUTS.

High-Tensile Bolts Replace Rivets

CE exclusive

J. L. McCOLLOUGH, Consulting Structural Engineer

HIGH-TENSILE BOLTS have replaced rivets in two new Florida office buildings that were originally designed for riveted construction. The two skyscrapers, in Jacksonville, Fla., were designed by the firm of Kemp, Bunch & Jackson, architects in Jacksonville. They are now almost completed. One of them, the Independent Life and Accident Insurance Company building, is to be 18 stories high. The other, the Prudential Insurance Company building, is to be 22 stories — the tallest building in Florida. Wind load, as required by the city building code on buildings of this height, is 30 lbs per sq ft horizontal pressure on vertical surfaces. This called for some heavy wind connections, especially in the Prudential building where the spans are long and the tower section is comparatively narrow.

The contract for furnishing and erecting some fifteen hundred tons of structural steel for the Independent building was awarded to the Bethlehem Steel Corporation. They immediately asked permission to substitute high-tensile bolts for rivets, chiefly because rivet crews were not obtainable. Also, they felt that the use of bolts would speed construction.

Very few people in this part of the country had had any experience with high-tensile bolts, and no large jobs had been built using them as connectors. Permission had to be obtained from the city building department after tests of the bolts were presented. Methods of inspection were outlined and approved. This inspection was to be in accordance with "Specifications for Assembly of Structural Joints Using High-Tensile Steel Bolts," approved by the Research Council on Riveted and Bolted Structural Joints of the Engineering Foundation, dated January, 1951. The paragraph on inspection stated: "The proper execution of the bolting operation shall be checked and approved by a procedure of loosening and retightening a certain proportion of the bolts. The proportion to be thus loosened and retightened shall

be specified in advance by the engineer." Between five and ten percent is recommended.

Bethlehem had used impact wrenches, and had evolved a method of calibration that is sufficiently exact. At the beginning of each day's work the wrench was used to turn up bolts in a tension measuring device. The tension was read on a gage attached to this device. The valve on the wrench was then adjusted to trip at the desired tension.

When the first section had been plumbed and bolted and the inspector had started the testing of the bolted joints, some startling facts were revealed. Approximately 20 percent of the bolts tested by loosening and retightening were found to be improperly tightened. In fact, one entire joint had been overlooked by the bolting crew.

Inadequate Inspection

Obviously the method of inspection being followed was not adequate, and a more positive method had to be devised. The entire section that had been tightened was checked and re-worked. It was decided that 100 percent inspection at all times was the only solution to the problem. The loosening and tightening test of five percent of the bolts gave no indication of the condition of the other 95 percent. The question also raised another problem as to whether the bolts so tested were damaged. The following procedure was adopted, and no further trouble with inspection was experienced:

¶ An inspector must be with the bolting crew at all times that tightening is in progress.

¶ Wrenches must be calibrated twice a day, and the time required for attaining the proper torque checked by a stop watch.

¶ Inspectors must check the tightening time with a stop watch, to satisfy themselves that the proper time is put on each bolt to give the required torque.

Tested by Hand

To conform to the code requirement, five percent of the bolts were tested with a hand wrench. When all bolts in a joint had been tightened to the satisfaction of the inspector, each bolt was marked with chalk. In this manner errors and omissions were practically eliminated.

It is interesting that in the revised specifications approved by the Research Council issued in February, 1954, the paragraph covering inspection has been changed to read as follows: "The inspector shall satisfy himself that all requirements of this specification are met. The inspector shall approve the procedure for calibration of wrenches and installation of bolts. The inspector shall further observe the field installation to determine that these procedures are followed. No other inspection is normally required. Where further inspection is required by the engineer, he shall specify in advance the method the inspector is to follow."

While bolting procedure and inspection progressed

WRENCHES HAD TO BE CALIBRATED TWICE EACH DAY IN THIS TENSION MEASURING DEVICE.

satisfactorily from this point, certain difficulties were encountered in the use of bolts. The steel floor decking was designed to rest directly on, and be welded to, the top flange of beams and girders. The wind connections were rather heavy, and consisted of top and bottom tee connections from the girder flanges to the columns. Angles (Fig. 1) were field welded to the top flanges of adjacent beams to support the decking. This allowed the top half of the cells to extend over the wind connections to receive the concrete fill.

Bolts Too Long

Bolts in these tee connections were normally inserted from the underside of the top flange and from the topside of the bottom flange so that the wrench could be applied to the nut from the top and bottom of the beam. It was soon discovered that in a great many cases the thickness of the connection plus the extension of the bolt itself (Fig. 2) kept the decking cells from passing over the connection — even though the bottom half of the cells had been cut away before shipment to the job. Therefore, it became necessary to reverse the placing of the bolts in the holes. The head of the bolt was put on top of the top flange, and on the bottom of the bottom flange. The wrench had to be applied to the nut from the inside of the beam, which made it necessary to use a universal joint attachment on the wrench. This attachment makes tightening of the bolt more difficult and slows the operation.

Tests were made at this point with the nut placed on the bolt and held stationary with a hand wrench while the impact wrench was applied to the bolt head. Thus the bolt turned instead of the nut. These tests proved satisfactory, but this method was not generally used and is not recommended until further studies and tests have been made. As a general rule, it would appear preferable to apply the torque to the nut itself, especially if the bolt shank is very long.

Exact Length Best

In all cases it is highly desirable, and sometimes essential, that the bolts be furnished in the exact lengths required by the connection to be bolted. Bolts that are too long will interfere with the forming of columns and beams that are to be encased in concrete, in addition to causing other troubles.

The contract for erecting about 5500 tons of structural steel on the Prudential building was awarded to the Ingalls Steel Construction Co., of Birmingham, Ala. Ingalls immediately requested a change from rivets to high-tensile bolts for the same reasons advanced by Bethlehem. Permission was granted. All the lessons regarding installation and inspection that had been learned on the Independent job were available to make the procedure on the Prudential job more efficient. In addition, Ingalls had just completed another bolted job, and could obtain experienced bolting crews immediately.

The field inspection on both projects was handled by the Pittsburgh Testing Laboratories, which had as many as three bolting inspectors on the job at one time. On both jobs, rivets were replaced with an equal number of bolts of the same size as the rivets, as required by the specifications.

Principal Advantages

From our experience, we feel that the main advantages in using bolts are:

¶ Riveting crews are difficult to obtain, while regular iron workers can be quickly trained to handle the impact wrenches.

¶ The installation cost is much lower with the use of bolts, since a two-man bolting crew alternating in the use of the wrench can install more bolts in a given period than a four-man riveting crew.

¶ While the wrenches are certainly not quiet, they are not as noisy as rivet guns. This becomes a big factor where the project is located in a city center.

¶ With the use of high-tensile bolts it becomes unnecessary to pull all joints tight with machine bolts prior to final bolting, thus reducing the number of machine bolts required for holding the members in place at time of erection, which makes big savings.

¶ Bolts, being made of special steel and in accordance with a tight specification, are of much higher quality than rivets and give a better connection.

¶ The method of installing high-tensile bolts and the method of inspection as outlined give a much more positive and known result, and a much more efficient connection than the ordinary riveted joint where each rivet is tested with a hammer. Many a loose or defective rivet has escaped the inspector's notice. Many another has been "tightened" by flattening the head, while the inspector was elsewhere, instead of being cut out and replaced.

¶ One of the greatest advantages in the use of bolts is in the ease with which a joint can be reworked or changed after the framework has been completed. This was amply demonstrated in one job where a major change was decided upon after the steel had been in place some time. This change required the removal and replacement of certain beams and pick-up columns, plus the beefing up of certain connections. The bolts were easily removed with impact wrenches without damage to the members. Where heavier connections were required, the holes in the connections were reamed and larger bolts used.

Principal Disadvantages

On the other hand, we feel the use of high-tensile bolts has several disadvantages:

¶ The initial cost of the bolts is about five times the cost of rivets, and the use of special washers increases this cost further.

¶ Special care must be exercised in the shop to insure smoothness of the surfaces to be bolted. Care

must be taken in the field to see that all faying surfaces are clean.

¶ Calibration of the wrenches requires careful checking. Together with the checking and maintenance of air pressure for the wrenches, this increases the cost of installation.

¶ The cost of inspection is much greater with the use of bolts, since the only sure method is to have an inspector with the bolting crew at all times.

However, it would appear that the advantages to be gained outweigh the disadvantages. The use of high-tensile bolts is comparatively new. Much more study and research is necessary to effect the economy which their use would seem to make possible. At the present time, the value given to a bolt is only equal to that given a rivet of equal size, meaning that an equal number of bolts must be used in a joint designed for rivets. Constant progress is being made in the improvement of materials, installation methods and equipment. This promises that a more realistic value will be given to each bolt, so that a joint can be designed using fewer bolts.

Improved Wrench

One of the greatest improvements in the installation of bolts to be expected in the near future is an improved impact wrench that can be automatically set to cut off at a given torque, eliminating some of the present detailed procedure. Rivets will always have certain uses, but soon their use in general field erection of buildings will be the exception.

The Research Council is constantly at work perfecting the present specifications. Some of the more important changes in the revised February, 1954 edition as compared to the January, 1951 code, (which was in effect during the erection of the Independent and Prudential buildings) are worthy of note. The original code stated that "The faying surfaces, when assembled, shall be bare, either descaled or carrying the normal mill scale. Faying surfaces shall be free of paint, lacquer, dirt, oil, loose scale, burrs, pits and other defects that would prevent solid seating of the parts or would interfere with the development of friction between the parts."

The revised code states that "The contact surfaces, including those adjacent to the washers, when assembled, shall be descaled or carry the normal tight mill scale. Contact surfaces shall be free of dirt, oil, loose scale, burrs, pits and other defects that would prevent solid seating of the parts. Contact surfaces of joints where slippage into bearing is acceptable may carry a shop coat of protective paint or lacquer. Contact surfaces of joints subjected to stress reversal, impact or vibration, or where stress redistribution due to joint slippage would be undesirable, shall be free of paint or lacquer." This revision allows more liberty in the use of shop paint, and therefore will tend to lower the fabrication costs.

New Code

Under the specification for assembly, the new code states that "Bolts shall be assembled with a hardened washer under the bolt head and nut as described in Article 2. Flat washers may be used if the abutment surfaces adjacent to the bolt head and nut do not have a slope of more than 1:20 with respect to a plane normal to the bolt axis; provided that, in all cases of non-parallel abutment surfaces, the nut shall be torqued against a non-sloping surface." This revision allows the use of more flat washers in place of beveled washers, further cutting the cost of materials.

These changes, together with the change in inspection requirements show a constant effort by members of the Research Council to perfect the specifications governing the use of high-tensile bolts. With added experience and research, the use of high-tensile bolts may become more general. ▲▲

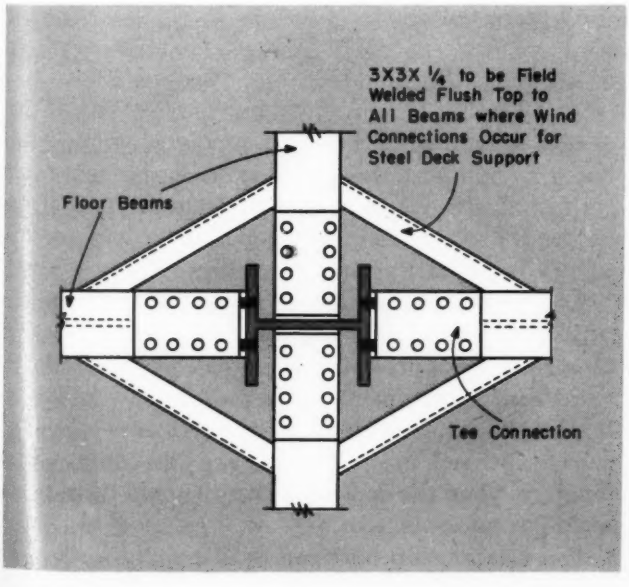

3X3X ¼ to be Field Welded Flush Top to All Beams where Wind Connections Occur for Steel Deck Support
Floor Beams
Tee Connection

FIG. 1—TYPICAL DECK SUPPORT AT A WIND CONNECTION ALLOWS DECKING CELLS TO EXTEND OVER CONNECTIONS.

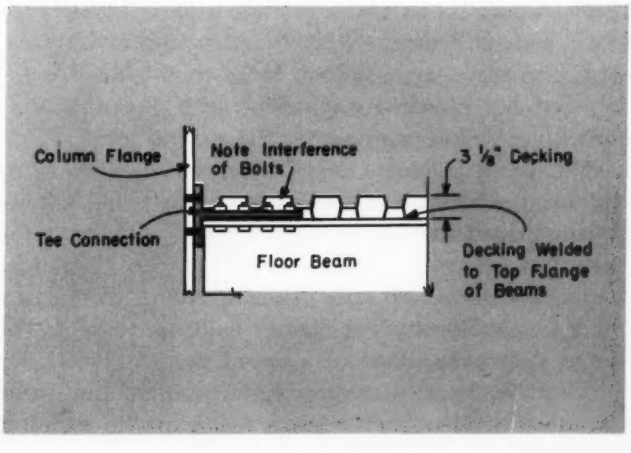
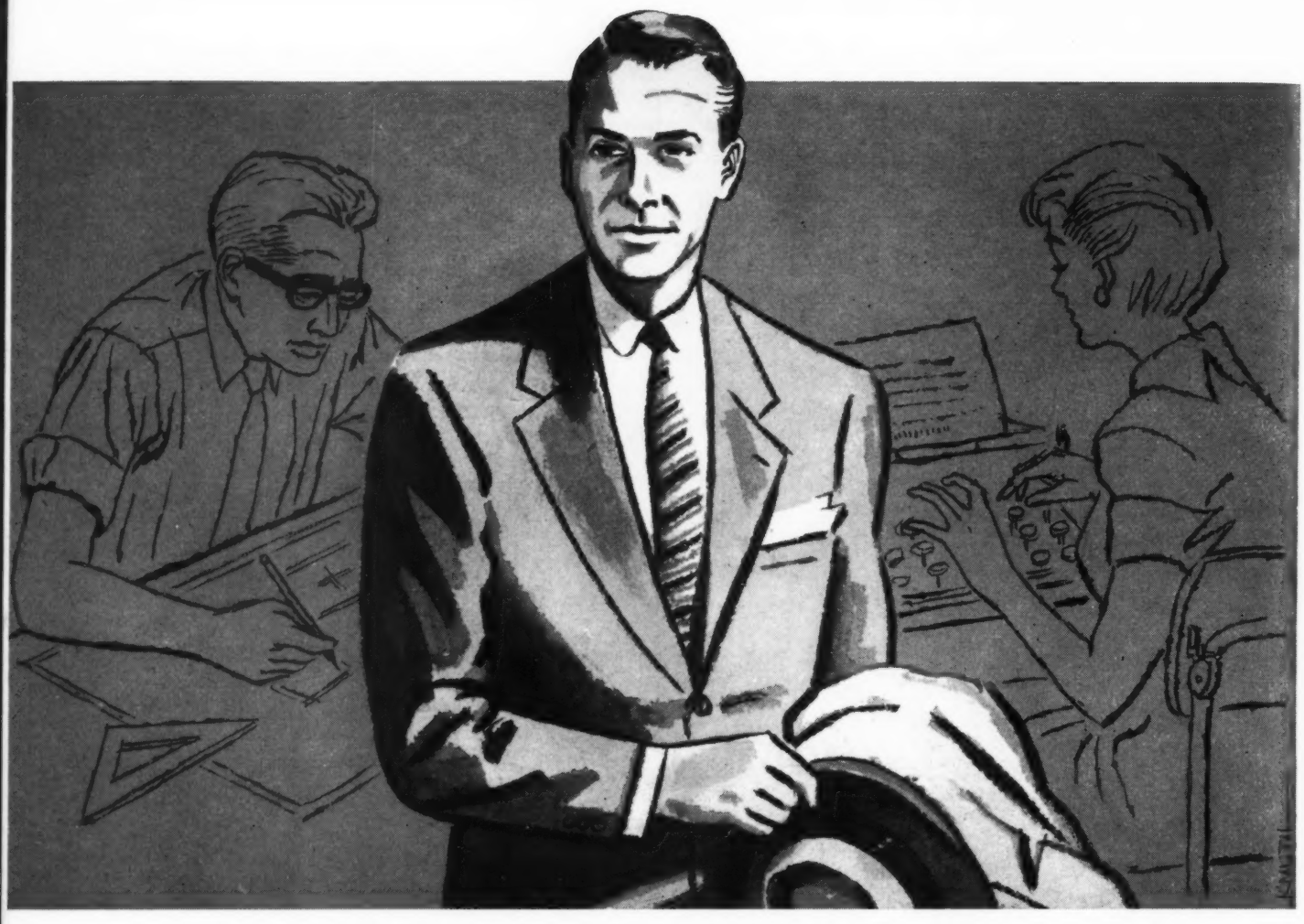


FIG. 2—THICKNESS OF CONNECTION AND BOLT PREVENT EVEN HALF-DECKING-CELL FROM LYING FLUSH ON BEAM.



ALTHOUGH DRAWINGS SERVE AS A MEANS OF COMMUNICATION FOR THE ENGINEER, ASKING HIM TO PRODUCE FINISHED DRAWINGS IS ANALOGOUS TO ASKING HIM TO TYPE HIS OWN LETTERS.

How Long Should He Be On the Board?

JOHN F. LEE, Professor of Mechanical Engineering
North Carolina State College

CE exclusive

CONSULTING FIRMS are finding themselves faced with stiff competition in attracting and retaining good engineering talent. More than ever, there is a need for creative engineers with the ability to quickly develop engineering judgment.

Militating against these objectives is the time-honored custom that engineers must be accomplished draftsmen and must come up through the drafting room. This custom fails to recognize that long experience on the drafting board develops a flair for detail which is diametrically opposed to the more desirable virtue of a broad perspective.

The insistence that engineers perform the functions of draftsmen represents a deplorable example of ineffective use of the short supply of young engineers. In addition, the salary scale of engineers who are also draftsmen inevitably reflects the time spent on the board — an effort that is usually less productive in terms of the firm's earnings.

A thorough reexamination of the place of drafting skill in the consulting office is needed, accompanied by a realistic appraisal of the engineer's attitude toward drafting as part of his professional responsibility. Industrial employers of engineers have already analyzed the problem, and the time passed long ago when the consulting firm should have made a similar analysis.

The relationship between drafting skill and engi-

neering has changed drastically in the past fifteen years. At one time engineering schools did devote sufficient time and effort to developing drafting skills so that the employer could expect reasonable proficiency in drafting among engineering graduates. This is no longer true.

The Engineer and Drafting Skill

Because of the demands of our rapidly advancing technology and the need to educate as well as to train engineers, there has been a marked trend away from the development of manual skills. In reality, there never has been a close correlation between manual skill and engineering ability. One could not reasonably expect an engineer to be an accomplished machinist. By the same token, it is unreasonable to expect him to be a proficient draftsman.

These attitudes did not originate with the engineering schools. Rather, they reflect the thinking of a majority of the employers of engineers. In a recent joint meeting of engineering educators and representatives from a group of industrial firms employing a vast number of engineers, the industrial representatives were in favor of eliminating drafting from the engineering curricula altogether. Thus it is clear that the consulting firm that insists on using engineers to perform many of the functions of a draftsman is facing a dwindling supply of such dual talent.

The problem is compounded still further by the attitude of the engineer. Many engineers are reluctant to spend a large amount of time on the drafting board. This attitude cannot be ignored. It stems, in part, from abuses of engineering talent in the past when young graduates were not in such short supply. There have been instances where the acceptance of an assignment on the drafting board has led undeservedly to a dead-end street. A more serious objection to drafting by the engineer is that he fails to derive the creative satisfaction expected of his professional experience when much of his time is spent on the techniques of producing a finished drawing.

If the engineer is not to do drafting, how is he to communicate his ideas to the man in the shop or in the field? Undeniably, drafting is a specialized form of communication.

In this instance, the question concerns the extent to which the engineer, as the originator of an idea, is to participate in formalizing the communication technique. It is analogous to asking if the engineer should type his own correspondence. The availability of a stenographer does not absolve him from the responsibility of using good English. Similarly, he must be able to convey his ideas in graphical form.

But is it necessary that he be skilled in producing a finished drawing? The employment of a draftsman, serving as an engineering aide in a role analogous to that of the stenographer, can produce a team in which the draftsman can supply the skill and attention to detail necessary to free the engineer for work in an area making more effective use of his talents. In such a team, the engineer needs to be able to prepare clear sketches and the draftsman must assume a responsible attitude toward minor decisions relating to detail. The ultimate responsibility for design decisions rests with the engineer who must approve the final drawings.

Draftsmen as Engineering Aides

Drafting is rapidly becoming a sub-professional activity or trade, as opposed to being a facet of engineering ability. The draftsman operating as an engineering aide serves a function in relation to engineering similar to that of nursing to medicine. This relationship is widely recognized by the growing number of technical institutes.

Viewed in this light the technically trained draftsman offers a number of advantages. His productivity as a draftsman is likely to be considerably higher than that of an engineer who has received only a modicum of training in mechanical drawing.

Drafting is an honorable and attractive trade, and the possible supply of trained draftsmen greatly exceeds that of engineers. Furthermore, draftsmen do not demand and cannot expect the salary scale established for professional engineers. Thus, when sub-professional men are assigned the responsibilities of drafting, the higher-priced abilities of the professional engineer are more effectively used.

To fully achieve these advantages the consulting office needs to take into account a number of factors. The function of the draftsman in the organization must be made clear. The newly hired draftsman must understand that his activity is sub-professional and is not a means of obtaining a position of engineering responsibility. It should be pointed out that it is a rare individual who moves up to an engineering position without formal engineering education. (However, to deny

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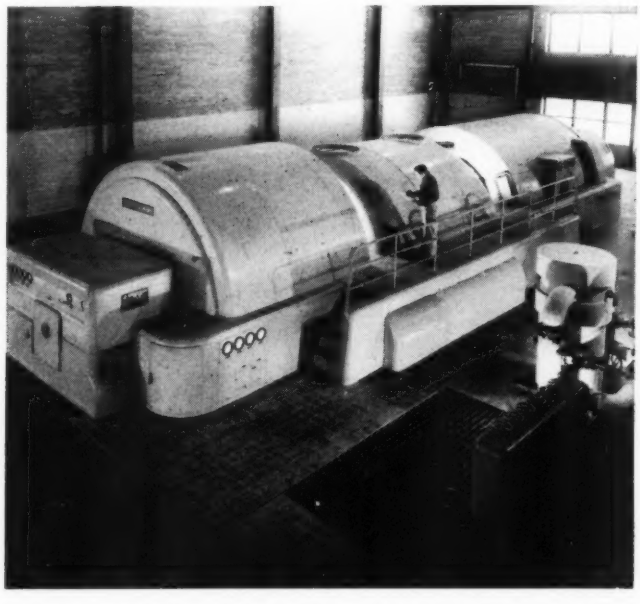
Cooling Techniques for Large Generators

Cp exclusive

In recent months we have seen increased interest in the performance of large turbine-generators. If machine ratings are to grow any larger, it will be cooling techniques that to a large extent will make such growth possible. There is some concern lest the new machines grow too fast. In the adjoining columns, authors from the three firms pacing the field give their thoughts on the way that cooling methods will affect machine growth.



THIS SUPERCHARGED HYDROGEN-COOLED TURBINE-GENERATOR IS RATED 75 MW AT 3600 RPM WITH REHEAT.

Supercharging Proven

L. T. ROSENBERG
Allis-Chalmers Manufacturing Company

SUPERCHARGED INTERNAL conductor cooling of turbo-generators, introduced in 1951, is the fulfillment of a dream that originated over 40 years ago. Heat had to be removed from generators if they were to grow in size. Early investigators of the cooling problem recognized that heat does not readily flow through electrical insulation. Several schemes were proposed and patented for bringing air around the insulation wall.

The necessary requirements for effective cooling were determined to be the following:

¶ The coolant (such as hydrogen) would have to be sealed against dirt and be circulated with moderate blower power and with moderate temperature rise from compression.

¶ The blower would have to be capable of developing several times the normal fan pressure previously used with conventional cooling.

¶ The design would have to be of such proportions

—Continued on page 44

Liquid Cooling Promising

C. E. KILBOURNE
General Electric Company

TECHNICAL PROGRESS in the art of generator design has moved forward at a rapid pace, especially within the last five years. Progress has been achieved principally by pushing back limitations. These limitations arise on several fronts: how to carry more magnetic flux, how to carry more electric current, how to insulate against higher voltages, how to construct the physical elements of the generators to withstand mechanical stress, and how to dissipate heat.

Among the most spectacular advances against these limitations are the developments in dissipating heat. By employing 30-psig hydrogen casing pressure, machines capable of delivering 220 mva at 3600 rpm and 245 mva at 1800 rpm are now in operation.

The new approach fundamentally responsible for the most recent advances in cooling techniques is the by-passing of the electrical insulation in carrying heat away from the conductors The current losses in the copper conductor raise the conductor temperature. It has been widely recognized that the insulation acts as a blanket to contain the heat within the con-

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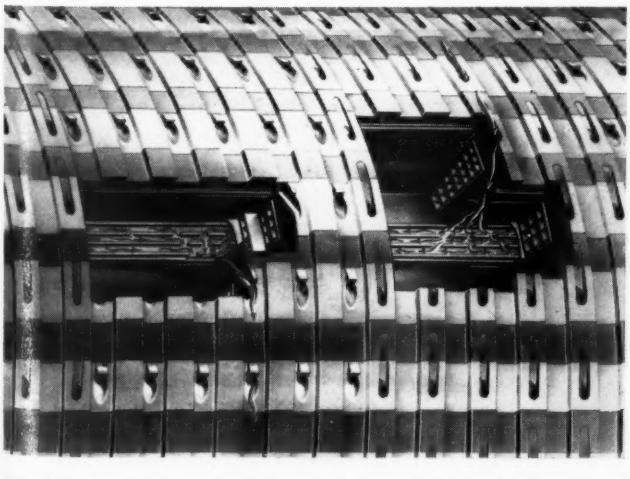
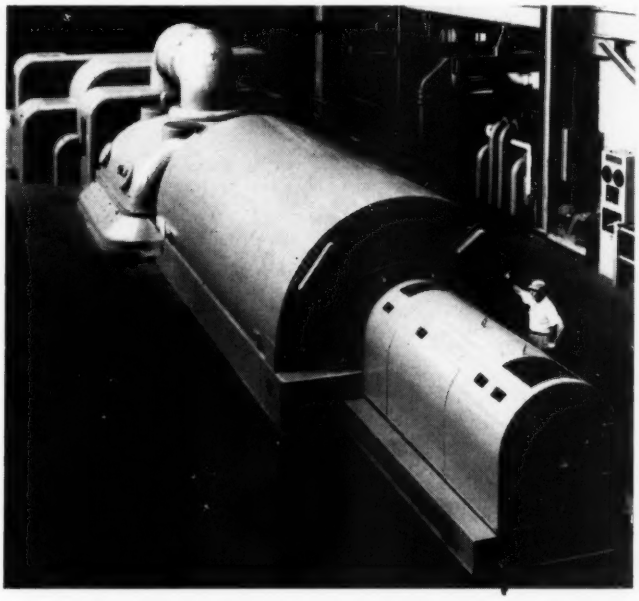


DIRECT-COOLED ROTOR SCOOPS UP HYDROGEN THROUGH IMPACT TUNNELS, EXPELS GAS THROUGH EXHAUSTS.



THIS RECENTLY INSTALLED HYDROGEN-COOLED TURBINE-GENERATOR IS RATED AT MORE THAN 110 MW.

Inner Cooling Sets Pace

W. C. BRENNER
Westinghouse Electric Corporation

THE URGE to improve turbine-generator performance led to development of the first hydrogen-cooled generator in 1926. The output of the generator was thereby raised 20 percent on a kilowatt-per-pound basis. Economies were made in construction material, power house space, material-handling facilities, and turbine fuel requirements.

Continuing desires to increase the specific output of generators led to application of successively higher hydrogen pressures. Conventional generators today can produce 25 percent more kilowatts at 30 psig hydrogen pressure than at 0.5 psig. However, the tendency to raise the rating by increasing the hydrogen pressure cannot be continued successfully with the conventional generator that has windings cooled only at the outer insulation surfaces. The inevitable thermal difference between the copper windings and the cooled surfaces cannot be elimi-

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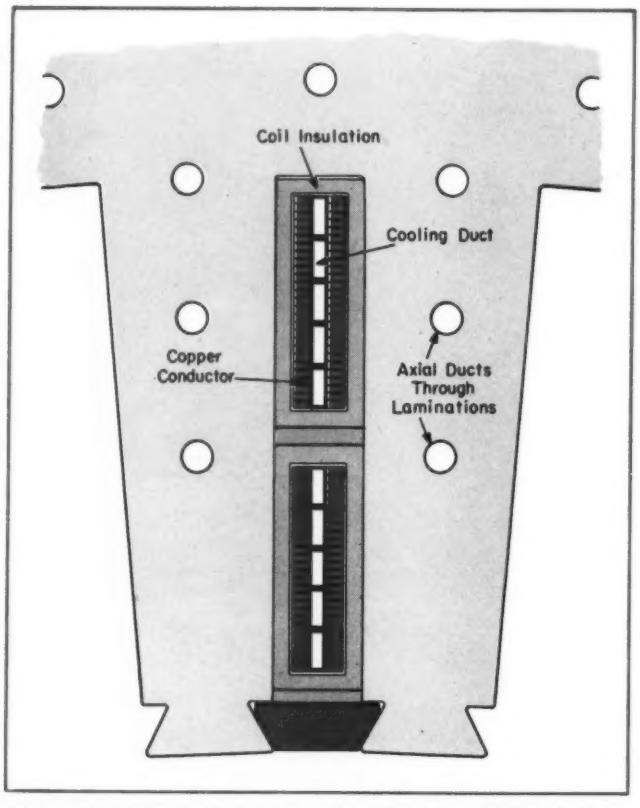


COOLING PASSAGES ARE DESIGNED FOR MINIMUM DUCT FRICTION AND INTIMATE CONTACT WITH EVERY STRAND.

Supercharging Proven

—Starts on page 42

that the required flow of cooling gas would be possible through the long conductors without exceeding the capability of the blowers.

¶ Ample conductor surface would have to be exposed to the gas to transfer the heat with but a small temperature drop.

¶ The cooling gas would have to travel over the copper surfaces at high velocity to improve the heat transfer coefficient.

¶ Mechanical support along the sides of the conductors would be needed to prevent distortion from thermal expansion forces.

Rotor Supercharging

As most large, high-speed generators had been limited in size mainly by rotor diameter, it was only natural for the new cooling principles to be applied to the rotor first. After more than a year of analytical and experimental investigation, designs were completed. Construction began on a 60-mw generator with a supercharged rotor. This unit was placed in service July 1, 1951. It has been in operation for 3½ years. During 1952 and 1953, the entire unit had an availability of 99.86 percent. The brief outages were due to minor factors not involving the generator.

Four similar machines with supercharged rotors are already in operation, and two others have been tested. Several more are under construction in ratings up to 134 mva, maximum.

Conventionally cooled stators of these partially supercharged machines are somewhat larger than normal in outside diameter to offset the shorter length made possible by the supercharged rotor. As a consequence, the thermal expansion of both stator and rotor is reduced, and an appreciable reduction in power plant space is possible when compared to a conventionally cooled generator of the same rating. The maximum load is only 125 percent of the nameplate value with gas pressure increased to 30 psig (because of the conventional stator), but the rotor becomes unusually cool as pressure is raised.

Supercharged Stator

To take full advantage of the new cooling principle, it was recognized that the stator must also be equipped with a means of internal conductor cooling. The admission of coolant into the stator conductors required careful study and experimentation to insure adequate dielectric strength at the coil ends. In the final analysis, though, generator ventilation as a whole is greatly simplified.

Both stator and rotor are cooled from one end to the other by a single-stage blower. The blower discharges hot hydrogen directly into coolers at the outboard end. Gas flows longitudinally along the cooler and thence back into the generator at the turbine end. Flow from this point is in parallel paths through the rotor coils, air gap, stator coils, and core.

The sketch on this page shows how the stator core is cooled. Many axial holes are punched in the laminations. The number, area, and placement of these holes are so proportioned that the core temperature will be nearly equal to the copper temperature, at full load. Tests indicate that only 6 C difference exists between the hottest strand and an embedded resistance detector at both 47- and 67-mva loadings on a machine operating at hydrogen pressures up to 70 psig. Thus, differential thermal expansion between the copper and the iron is mini-

mized. At the same time, the major supply of hydrogen is conserved for the coils. This axial cooling of the core eliminates the usual radial ducts as well as the large ducts commonly around the outer periphery of the core.

For end-to-end rotor cooling, the maximum temperatures at the discharge end can be lowered by staggering the inlet and outlet openings on the two sides of the conductors, and by using the principle of partial gas entry in the coil ends. This increases the copper temperature somewhat at the cool end, but the ratio of maximum-to-average temperature can be held as low as 1.28 to 1.00 with this design. For very long rotors, requiring disproportionate ventilating pressure, the gas would flow from both ends toward the center in the manner now used successfully for rotor supercharging. A temperature rise of 85 C would be considered safer on such a rotor than on the conventional machine of the same rating but of correspondingly longer length.

Reactances

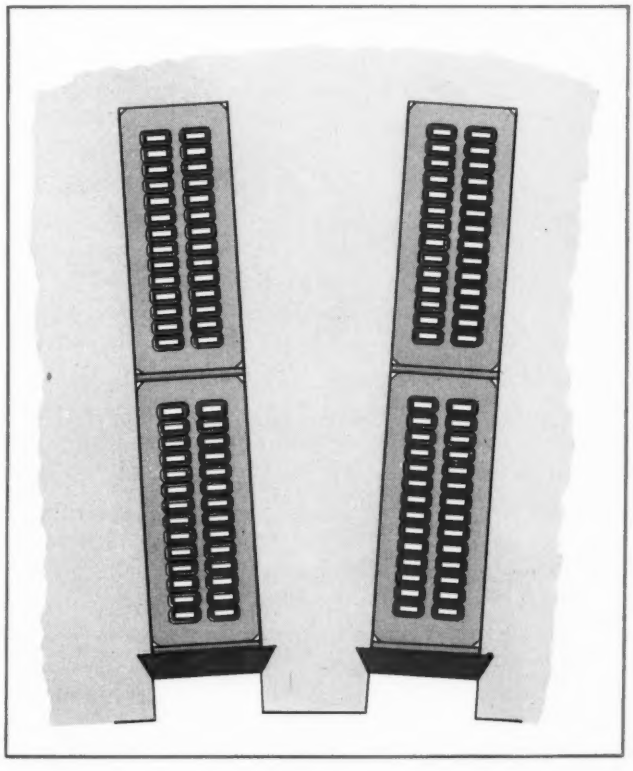
The reactances of the fully supercharged machine are about the same as those of a conventional 1800-rpm unit. This means that less-costly circuit breakers are required for a given rating, and there is less likelihood of serious injury at the point of a fault or from mechanical forces.

There is little doubt that most large 3600-rpm generators will ultimately be cooled by forcing the cooling medium through ducts inside the insulation wall. Complete supercharging takes full advantage of high gas pressure. The hazards of differential thermal expansion are reduced because of the shorter machine length, lower average temperature, and lower temperature difference between copper and iron.

The higher magnetic circuit saturation improves the steady-state stability of the supercharged machine. The problem of increased excitation has been solved by the new commutatorless exciter-regulator. Compact design conserves hydrogen and facilitates shipment. The reduced generator weight and length reduce bearing and seal maintenance as well as building, crane, and foundation costs.

The high reactances of the supercharged unit afford a welcome return to the moderate fault currents and low circuit breaker interrupting duties characteristic of the old days of the four-pole machines. Although the new cooling principle is best suited to 3600-rpm units because of the favorable blower speed, it may eventually be adapted for 1800-rpm generators by employing separately driven blowers.

Tests show that with the high efficiency obtainable in the centrifugal blower and the relatively low cfm needed for supercharged cooling, windage losses are not greatly increased over conventional cooling despite the high blower pressure. Single-shaft, 3600-rpm generators of this type are possible in ratings exceeding 300 mw, at 45 psig, with materials now available. If higher output is needed, machines with hydrogen pressures from 70 to 100 psig will yield further gains. Such machines appear to be justifiable. ▲▲



CROSS-SECTION OF STATOR BARS DESIGNED WITH TUBULAR STRANDS SUITABLE FOR INTERNAL, LIQUID COOLING.

Liquid Cooling Promising

—*Starts on page 43*

ductor. Efforts had been made to develop insulations that would withstand thermal deterioration to permit operation at higher temperatures and to develop insulations with better thermal conductivity — all in an attempt to reduce the blanketing effect of the

insulation. The gains on these fronts were quite modest compared with the possibilities of cooling the conductors by direct contact with cooling fluids.

To by-pass the thermal drop across the insulation in stator windings, internal gas cooling passages have been built within the stator conductors. The gas ducts are made of stainless steel, insulated from one another, and insulated from the copper strands by thin walls of insulation. A fan on the rotor forces the cooling gas through the stator.

There are disadvantages to gas cooling of the stators. These lie in the losses sustained in the fan, the costs of an aftercooler for the gas, electric problems at the stator winding ends, and the effect of these cooling methods on the operating procedures.

Liquid Cooling

Presently, the most promising method of stator cooling uses liquid coolant instead of gas. Present indications are that liquid cooling of the stator will virtually eliminate the thermal limit on armature design, and will be a powerful tool in increasing armature capacities even further. The liquid circuit is very efficient. Liquid cooling will require only a few horsepower for a circulating pump compared with about 100 horsepower consumed in the multi-stage circulating fan necessary in the gas cooling method.

Liquid is adaptable to almost any type of electrical connection, and is quite flexible with respect to the balance between current and voltage. In contrast, the gas cooling system usually dictates use of higher voltages as the kva capacity of the machine is increased. The disadvantages of liquid cooling are chiefly confined to the plumbing details for containing the liquid. To guard against minor leaks, a positive pressure differential between the hydrogen (for rotor cooling) and the cooling liquid can be established. Not only will this prevent discharge of fluid, but it will establish immediate leak detection through monitoring of the hydrogen content in the fluid. Major leaks, if any occur, can be spotted by liquid-level alarms also.

Rotor Windings

Cooling rotor windings is predicated on the same basis as is stator cooling: by-passing of the conductor insulation in carrying heat from the conductor. Several of the earliest attempts at direct cooling of rotor windings shared the idea of intimate contact between coolant and conductor. Ventilation spaces were placed on the sides or through the center of the windings as well as down the center of the conductors themselves. The most desirable method seemed to demand axial flow of gas through the end turns along the outer portions of the rotor body length, with some method of introducing fresh cooling gas into the center of the rotor body length.

Impact Tunnels

The most modern cooling arrangements now use axial ventilation for the end portions of the rotor body with air gap ventilation for the middle portion. Radial openings on the surface of the center portion of the rotor scoop up cool gas from the air gap and channel it through impact tunnels to the conductors. After flowing along the conductors, the warmed gas is expelled through an outlet tunnel similar to the impact tunnel. Rotation of the rotor develops a suction head at the outlet tunnel to augment the positive head at the impact tunnel entrance.

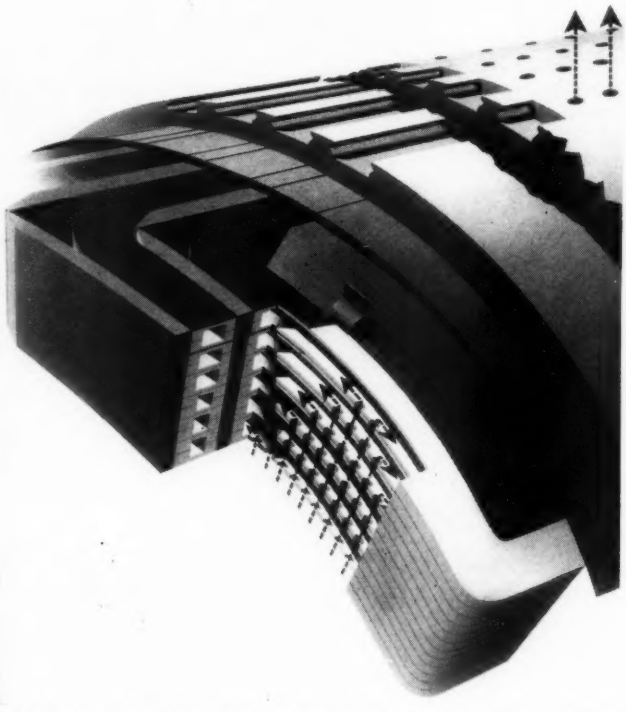
This method of rotor cooling promises a 2.5 per unit increase in rating for a 100-mva unit, at 3600 rpm and 30 psig hydrogen pressure — assuming thermal phenomena as the sole factor limiting design. Thus, as in the case of the stator, thermal limits have been moved to new horizons.

The use of large generating units results in decreases in installed cost per kw and in operating labor per kwh generated. Present indications are that the trend to large generator sizes will continue. It does not appear possible to predict today what the economic, ultimate size of individual units may be.

Operating Costs vs. Efficiency

Many large generators today have efficiencies very close to 99 percent, so that the problem of maintaining efficiency levels along with increased output becomes important. While the problem of maintaining high efficiency is difficult when the output is doubled, progress is being made on the problem at more modest increases in output. Ways will be found to obtain both high efficiency and high output. However, even if a temporary, small sacrifice in efficiency must be made in a few cases, the sacrifice may be offset by the savings from the use of larger units (from lower installed cost per kw, and lower operating costs per kwh), making the increased rating attractive.

Further increases in generator capability will probably find some large generators with two sets of bushings feeding parallel bus runs in place of very-high-capacity single bus runs. Also, development of new generator bushings and bus duct for handling currents above 11,000 amperes is under way. Forced-cooled busses are being considered. ▲▲



COOLING GAS ENTERS FROM BELOW AT END TURNS, PASSES THROUGH COILS, ENTERS AIR GAP AT CENTER.

Inner-Cooling Sets Pace

—*Starts on page 43*

nated by increased gas pressure. Even assuming "perfect" cooling, the possible theoretical gains are slight when comparison is made with the ratings already available today at 30 psig hydrogen pressure.

Direct Cooling

A new approach to the ventilation problem had to be found if specific ratings were to be increased. Direct cooling at the heat source was the answer. The principles were not new, for the application of cooling gas to heated surfaces was well understood, and had been successfully applied to the cooling of conventional generators. The latest innovation is in the direct application of the hydrogen to the copper windings as opposed to cooling the outer surfaces of the insulating sheath surrounding the copper. This new method is called "inner-cooling."

Already built and installed is an inner-cooled generator rated 100 mw at 45 psig hydrogen pressure. A 156-mw unit is being built now. Two units, each rated 250 mw, have been scheduled for completion in 1955. These represent some of more than 4000 mva in generator capacity built or on order with capacity rated at 45 psig hydrogen pressure. The continuous long-time trend is toward larger unit capacities plus higher specific output ratings.

The inner-cooled generator is a model of simplicity. Ventilation is accomplished easily by a blower that produces a high differential pressure between two major zones within the generator. Tubular passages in both the stator and the rotor coils permit sufficient hydrogen to flow to cool them effectively. The cooling circuit is not only simple, but it is almost foolproof. There is no necessity to isolate or segregate a number of different cooling media with internal baffles, each of which would be subject to a number of undesirable leaks.

With inner-cooling, the cooling rate (or, conversely, the permissible heat dissipation rate at safe temperatures) is almost unlimited. The only prerequisite is that the mass-rate-of-flow of gas must be increased at approximately the same rate as the heat release rate.

Effective Limits

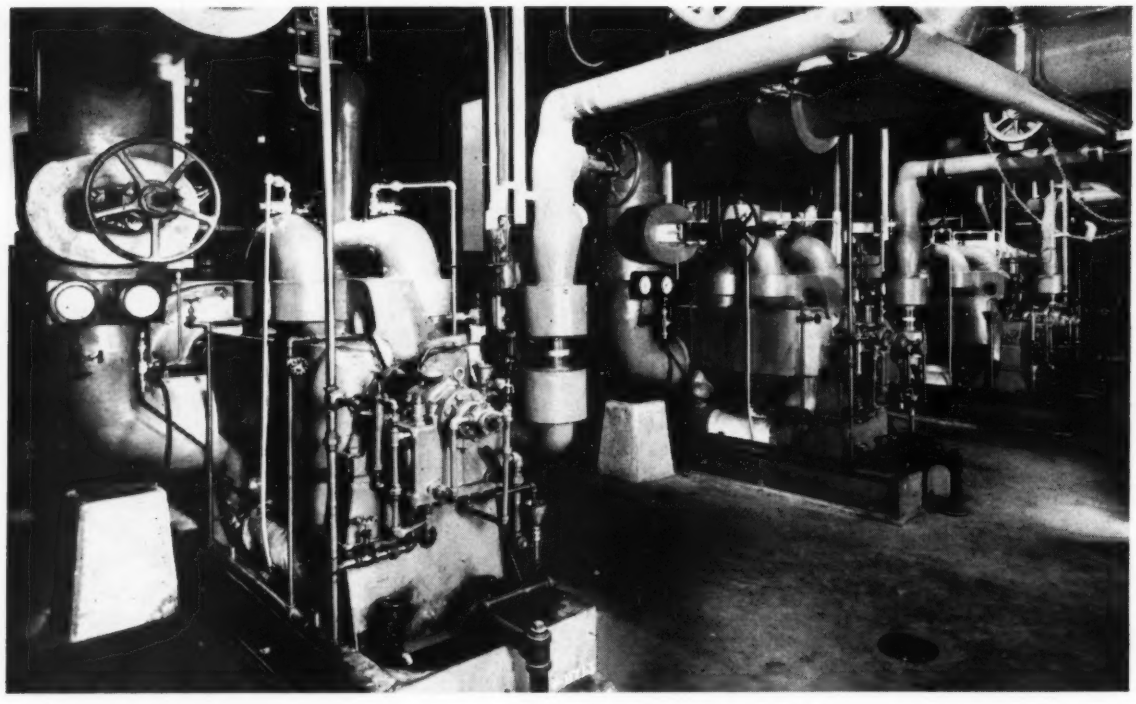
One of the effective limits to the capacity of a single generating unit is physical size. Physical size is limited by the maximum size of the rotor that may be used. On the one hand, the strength of the materials used limits the rotor diameters. On the other hand, the flexibility or resonant frequency is so related to the rotor length as to set a practical limit in that direction.

Although it is possible to create generators with much greater capacities, the practical limit will still be determined by the fact that the variable or load-dependent losses tend to increase at a rate proportional to the square of the specific ratings, causing a drooping efficiency characteristic when the load-dependent losses are greater than the constant losses.

Inner-cooled generators are in a class by themselves at ratings above the ceiling set on conventional generators. While already on a drooping efficiency characteristic, they are still competitive with conventional units on an efficiency basis. This same characteristic affords better-than-normal performance at part loads. Inner-cooled generators are less bulky, require less in the way of handling facilities, are smaller in size than conventional units, take less floor space, and require less rotor-removal space.

Our largest generator on order has a rated output of 261 mw at 30 psig hydrogen pressure. It is antici-

—*Continued on page 78*



THREE 6-STAGE CENTRIFUGAL BOILER FEED PUMPS SERVING TWO BOILERS. RATED AT 500,000 LB PER HR FOR 270 F FEEDWATER, THE THIRD UNIT SERVES AS A STANDBY FOR BOTH BOILERS.

How Many Feed Pumps Should You Specify?

Cp exclusive

IGOR J. KARASSIK, Manager, Multistage Pump Section
Centrifugal Pump Div., Worthington Corporation

WITH THE HIGHER operating pressures being used in modern steam power plants, boiler feed pumps are becoming larger and consume more power. Because of the greater power consumption, consulting engineers are finding that the selection of the proper number of pumps is becoming increasingly more important.

In a base load station, the tendency is to specify one feed pump per boiler—a unit with sufficient capacity to meet the maximum steaming rate plus a margin for load fluctuations and pump wear. But if the load is of a frequently fluctuating nature, two or more pumps are often operated in parallel. During periods of light load, the extra pumps can be taken off the line, permitting more efficient operation.

There are two exceptions to this general practice, however. Because of their importance, perhaps these exceptions should be the general rule. The nature of the load and its effect on the final choice of the number of pumps would then become a modifying factor for marginal cases where the general rule does not yield a clear-cut decision. The exceptions are:

¶ When the total capacity is too low to be economically and effectively split up between two pumps, a single pump should be used regardless of the nature of the plant load.

¶ When the maximum capacity is too great to permit the use of the most economical size of boiler feed pump, the capacity should be split up between two or more pumps. This, again, holds true regardless of the nature of the plant load.

Power Consumption

These two exceptions are based upon economy and efficiency—in other words, first cost and relative power consumption.

To illustrate the problem of power consumption,

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consider an example in which the feed pump installation is intended to serve an 850-psi turbo-generator with a maximum boiler steaming rate of 450,000 lb per hr. Assume that the total operating capacity is 500,000 lb per hr, that the pumps handle feedwater at 300 F, and that the net pressure for which they are to be designed is 1100 psi.

The range of capacities in this example brings the feed pump selection within the first exception. Referring to Fig. 1, it is seen that the efficiency of a pump designed for 500,000 lb per hr differs very little from that of a 700,000 lb per hr unit, but reducing the capacity below 300,000 lb per hr introduces a very rapid decrease in efficiency. Thus, the efficiency of two pumps of half-capacity in parallel is considerably less than that of a single full-capacity unit. Even if the plant would operate at capacities of less than 50 percent some of the time, whatever gain in power consumption that might be obtained by using a single half-capacity pump at these light loads would be more than offset by the loss in power consumption when the plant is operating at a capacity requiring both pumps.

An even more unfavorable comparison would result if, as is frequently the practice in some plants, the operators do not shut down one of the two pumps when the load on the boiler falls to 50 percent or

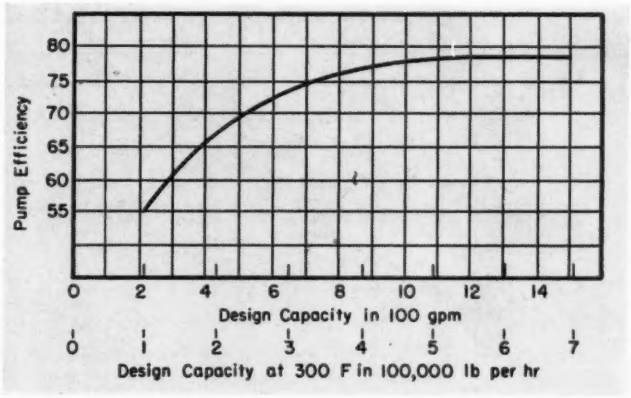

FIG. 1 — EFFICIENCY OF A 3600 RPM BOILER FEED PUMP DESIGNED FOR 1100 PSI NET PRESSURE.

less. With such operating practice, there is no saving whatsoever by using two half-capacity pumps, but rather a definite loss under all operating conditions.

A comparison of the power consumption over the entire operating range for both the single and two pump installations is presented in Tables 1 and 2. It is further illustrated graphically in Fig. 2. To simplify the analysis, it has been assumed that the temperature remains constant at all loads. Actually, it

TABLE 1 — POWER CONSUMPTION OF ONE PUMP FOR FULL FLOW

Flow in lb per hr	Percent of Pump Design Capacity	Percent of Pump bhp at Design Capacity	Pump bhp
100,000	20	52	466
150,000	30	58.5	524
200,000	40	66	591
250,000	50	72.5	650
300,000	60	79	707
350,000	70	85	761
410,000	82	91.5	820
450,000	90	95.5	855
500,000	100	100	895

TABLE 2 — POWER CONSUMPTION OF TWO PUMPS FOR FULL FLOW

Flow in lb per hr	No. of Pumps Operating	Percent of Pump Design Capacity	Percent of Pump bhp at Design Capacity	Pump bhp (each)	Total Pump bhp
100,000	1	40	66	324	324
150,000	1	60	79	388	388
200,000	1	80	90.5	445	445
250,000*	1	100	100	492	492
250,000*	2	50	72.5	356	712
300,000	2	60	79	388	776
350,000	2	70	85	418	836
410,000	2	82	91.5	450	900
450,000	2	90	95.5	470	940
500,000	2	100	100	492	984

*Whether one or two half-capacity pumps are left operating at half the design flow depends on the stability of the load and on the preference of the operators. A single pump will probably be capable of carrying the load up to 300,000 lbs/hr, but this is seldom taken advantage of except in emergencies.

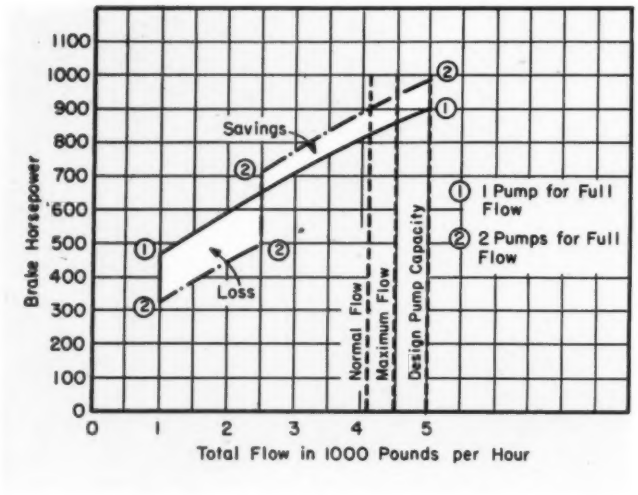

FIG. 2 — POWER CONSUMPTION OF A 500,000 LB PER HR PUMP COMPARED TO TWO 250,000 LB PER HR UNITS.

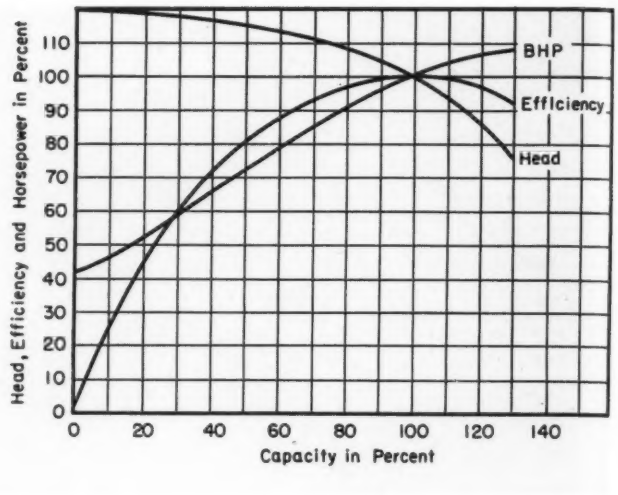

FIG. 3 — EFFICIENCY, POWER CONSUMPTION, AND CAPACITY OF A 6-STAGE, CENTRIFUGAL FEED PUMP.

would be reduced to some degree as the load is reduced. This simplification does not introduce a very appreciable deviation and therefore does not affect the solution to our problem.

To permit a quantitative analysis of the example, assume that a single pump has been selected to handle 500,000 lb per hr of 300 F feedwater against a net pressure of 1100 psi. Referring to Fig. 1, its efficiency would be 78 percent. According to Table 1, the power consumption would be 895 bhp. If two pumps of 250,000 lb per hr were used, the pump efficiency would be 71 percent and the power consumption per pump would be 492 bhp, as shown in Table 2. The total for both units would be 984 bhp.

Using terms somewhat closer to normal operating conditions for this installation, assume that the maximum flow is 450,000 lb per hr and that the normal load is 90 percent of this maximum. The normal flow to the boiler, therefore, would be 410,000 lb per hr, or 82 percent of the pump's design capacity of 500,000 lb per hr. At this flow, the pump brake horsepower is 91.5 percent of the design brake horsepower (see Fig. 3). Thus the power consumption with a single full-capacity pump would be 820 bhp while it would be 900 bhp with two half-capacity pumps. This savings is shown in Fig. 2.

Operating Hours

To be of real value, the comparison should be carried further on the basis of the number of operating hours at various loads. The distribution of operating time for each load varies with every installation. Table 3 presents a typical analysis of power savings. It indicates that a total of 273,220 hp-hr would be saved yearly, under a specified loading, through the installation of a single full-capacity pump when com-

TABLE 3 — ANALYSIS OF POWER SAVINGS ON A YEARLY BASIS

Total Flow in lb per hr	*Assumed No. of Hrs per Year*	*Total bhp with One Pump*	*Total bhp with Two Pumps*	*Excess in hp-hr by Use of Two Pumps*	*Savings in hp-hr Through Use of Two Pumps*
100,000	390	466	324	—	55,380
150,000	400	524	388	—	54,400
200,000	500	591	445	—	73,000
250,000*	500	650	492*	—	79,000
250,000*	500	650	712*	31,000	—
300,000	1000	707	776	69,000	—
350,000	2000	761	836	150,000	—
410,000	2500	820	900	200,000	—
450,000	1000	855	940	85,000	—
TOTAL	8790 hrs.			535,000	261,780

Net saving through use of single pump..... 273,220 hp-hrs per yr.

*(See Table 2)

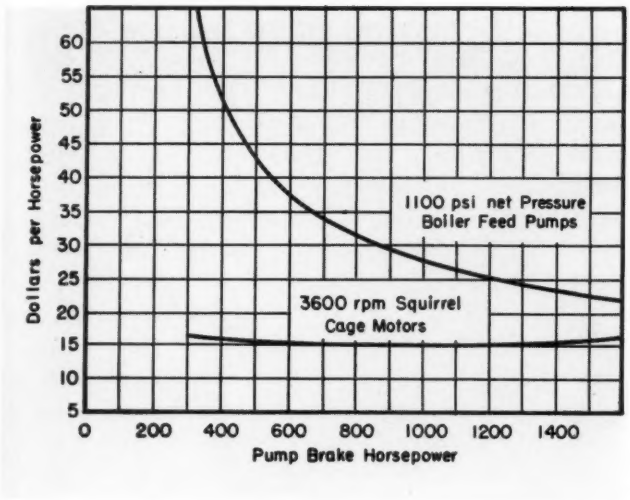

FIG. 4—EFFECT OF SIZE ON THE COST PER HORSEPOWER OF BOILER FEED PUMPS AND ELECTRIC MOTORS.

pared to two half-capacity pumps. Assuming an approximate motor efficiency of 92 percent and a cost of 0.5 cents per kw-hr, this represents a saving of approximately $1100 yearly—not an overwhelming saving but still on the plus side of the ledger. Of course, a more heavily loaded station would have shown still greater savings with this type of analysis applied to it.

A lesser total capacity (such as 300,000 lb per hr instead of 500,000 lb per hr) would also indicate a greater saving through the use of a single pump, since the drop-off in efficiency is more rapid with further reduction in capacity, as indicated by Fig. 1.

This analysis has been limited to constant-speed, motor-driven, boiler feed pumps. The introduction of variable-speed operation would have somewhat complicated the analysis. The advantages of variable speed operation are appreciably reduced with the reduction in boiler feed pump size. Although the power savings might justify a variable speed drive for the single full-capacity pump in our example, it probably would not prove to be advantageous if two half-capacity units had been used.

Initial Costs

If power consumption indicates the superiority of the single full-capacity pump over the half-size units in our example, what then of the first-cost considerations? Here again, economic factors favor the single-pump solution for the lower ranges of capacities.

Since a spare pump will be installed in either instance, compare the cost of two full-capacity pumps driven by 900-hp, 3600-rpm squirrel-cage motors to that of three half-capacity pumps driven by 500-hp motors. Consider further that, in the majority of installations, a spare rotating element will be purchased. Its cost should be added in each of the two solutions.

The current price of two full-capacity pumps, with five-percent chrome steel casings and stainless trim, plus their motors and a spare rotating element, would be approximately $89,000. Three similarly fitted half-capacity pumps, plus their motors and a spare rotating element, would cost $95,000—almost 7 percent more. To this higher cost would have to be added the extra cost of the starting equipment plus that of extra piping, valves, and controls, plus the value of the additional space occupied.

The question arises: why these savings? For the most part, the answer comes from the fact that while the price of motors (expressed in dollars per horse-

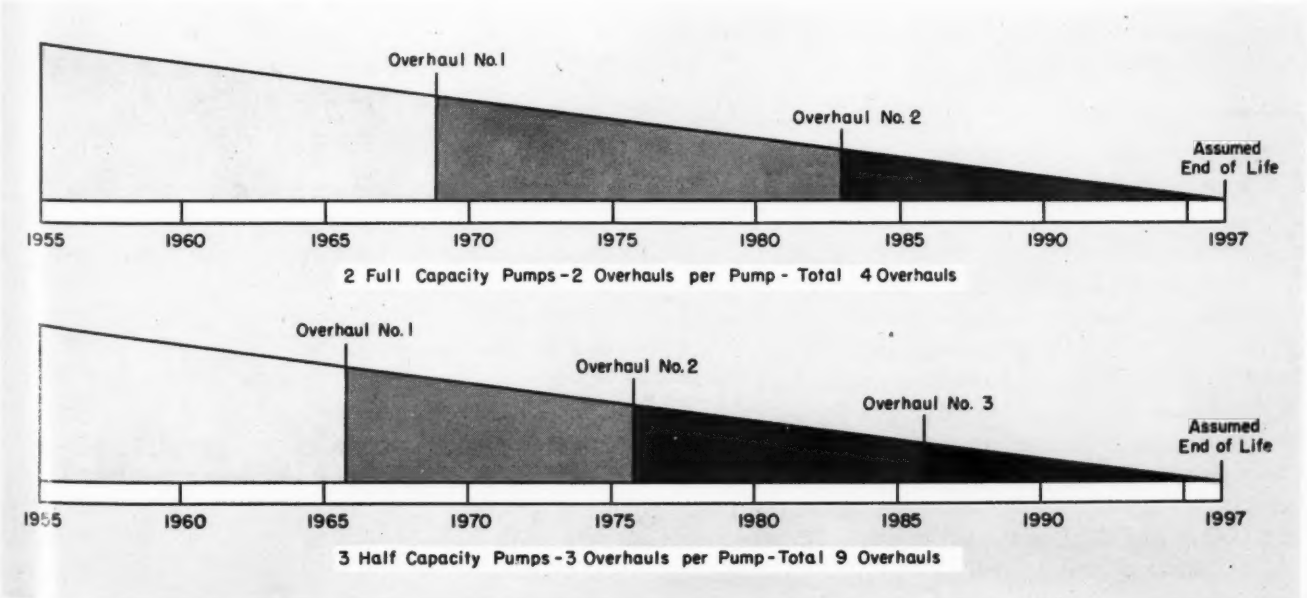

FIG. 5—WHEN 7 OPERATING YEARS BETWEEN OVERHAULS AND A TOTAL LIFE OF 42 YEARS IS ASSUMED, TWO FULL-CAPACITY PUMPS WOULD REQUIRE 4 OVERHAULS WHILE THREE HALF-CAPACITY UNITS WOULD NEED 9 OVERHAULS.

power) is almost constant over a wide range of sizes, the price of boiler feed pumps (similarly expressed) drops very appreciably with size. This relation is shown in Fig. 4.

A 500-hp pump costs 55 percent more per horsepower than a pump double that size. Expressed in different terms, a 1000-hp pump costs only 27 percent more than a pump of 500 hp. When it is further considered that, because of the differences in efficiency, a 900-hp pump will handle twice as much capacity against 1100 psi as two 500-hp pumps, doubling the capacity increases the cost of the pump by only 22 percent.

This cost relationship is easily understood. Both pumps will likely have the same number of stages. If they do not, it is the smaller capacity pump that will have more stages. While the weight of the larger pump will be greater, there will be approximately the same number of machining operations in making it. The assembly of both pumps will require approximately the same amount of time.

Reliability

Reliability is another factor to be considered. This is a realm of intangible factors, and personal opinions may differ widely. One point of view holds that the use of two full-capacity pumps is equally reliable in the light of the greater dependability of modern pump construction.

If emergency problems are considered and it is assumed that a full-capacity pump has been damaged because of flashing or similar malfunctioning, there still remains a spare full-capacity pump to bring on the line after the original trouble has been corrected. But if three half-capacity pumps had been installed and two of them were operating at the time of the emergency and flashing, there is a possibility that both pumps would have been damaged. This would leave a single pump of only 50-percent capacity to put on the line.

Maintenance Expense

The final factor in cost analysis is maintenance expense. Assume that, in both instances, each of the pumps is operated for equal periods of time so that the wear is shared equally between all the pumps. If a lifetime of 42 years is assumed, each of the two full-capacity pumps will have operated a total of 21 years. Each of the three half-capacity pumps would have operated 28 years. Assuming a minimum life of 60,000 hours (7 years) between overhauls, each of the full-capacity pumps will have been overhauled twice—once at the end of each seven years of operation (14 elapsed years). Since the life of the plant is 42 years and the life of each pump is 21 years, the third overhaul will coincide with the end of the equipment's life and therefore does not need to be counted. Thus, a total of four overhauls will have been made during the life of the installation.

With half-capacity pumps, each unit has an operating life of 28 years and it will have three overhauls—one each at the end of 7, 14, and 21 years of operation. Here again, the overhaul at the assumed end of each pump's life is discounted. A total of nine overhauls for the three pumps, therefore, will have taken place—2¼ times the number of overhauls required for two full-capacity units. This relationship is shown in Fig. 5.

Applications for Two Pumps

So far, this article has discussed only the range of capacities where considerations of efficiency as well as of first cost favor the use of single full-capacity pumps. What of the second exception to our general rule—the case where the maximum capacity is too great to economically permit the use of one pump?

From the studies carried out to date, it appears that a single-pump installation is preferred for plants up to 60,000-kw size, regardless of the operating pressure. Once this size is exceeded, the choice is less definite. From the point of view of operating economy, there is nothing to be gained at full load with full-capacity pumps, while at reduced loads there may be much to be gained by using two or more pumps in parallel. If a curve similar to Fig. 2 were plotted for a 100,000- or 200,000-kw installation, it would indicate practically no savings in the right-hand region but would show considerable losses in the left-hand portion of the curve as a result of using a full-capacity pump.

Initial Cost

As to initial cost, it becomes quite apparent from Fig. 4 that the cost per hp of boiler feed pumps asymptotically approaches a minimum value. The cost per horsepower of the electric motors, however, begins to increase once the motor size exceeds 1250 hp. The total cost of two full-capacity pumps and their drivers begins to exceed that of three half-capacity pumps and the three motors, until the picture becomes very dark indeed for the full-capacity combination.

In addition, as a motor becomes larger, the increased starting current and larger transformer sizes begin to introduce problems that had not heretofore existed. Thus, unless some other new factors are introduced, such as the use of high-speed pumps or the use of steam- or gas-turbine drives, units of 100,000 kw and more will generally be better served with half-capacity units. In fact, as the size of the units continues to grow beyond the present 260,000-kw maximum, conditions will be reached where the total capacity may best be split up between three pumps. In such instances, serious consideration can be given to eliminating the spare boiler feed pump, since emergency outage of one of three pumps will, generally, still permit the operators to carry up to 80 percent of the maximum load. ▲▲

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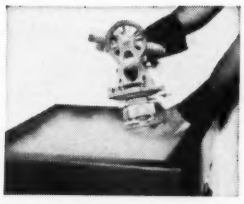

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. . . national debt and stability

CONSULTING ENGINEERS have an interest in the national debt as it affects stability of the economy. Debts are characteristic of national governments. As a matter of fact, it is a very rare occurrence for a government to be free of debt—something that has not occurred in our country since 1837. The importance of the national debt increases with its magnitude. And debts of great magnitude are almost always the product of national crises—the greatest being war, with depression spending a very poor second.

Size of the Debt

At the close of World War II, we were left with a national debt amounting to something over $278 billion—the largest debt ever assumed by any nation in the history of the world. Early in 1949, the debt had been reduced to about $250 billion. Since then, it has been increasing until now it is again over $278 billion. Present forecasts call for a continuing increase in the national debt during the next fiscal year, beginning July 1, 1955.

Let us attempt to reduce the size of the debt to more understandable numbers. Our present national debt represents a debt of roughly $1900 per man, woman, and child. Compare this $1900 to the per capita debt of $19 in 1790, $15 after the War of 1812, $78 after the Civil War, and $240 after World War I.

Significant comparisons can be made between the debt and the national income and between the interest paid on the debt yearly and the national income. Immediately following World War II, for the first time in our history, the debt exceeded the annual national income. (At the present time, the national income, because of its rapid real growth as well as the inflated price level, has outpaced the national debt and has pulled ahead of it.) But after the Civil War, the debt was approximately one-half the national income; after World War I, it was approximately two-fifths of the total national income.

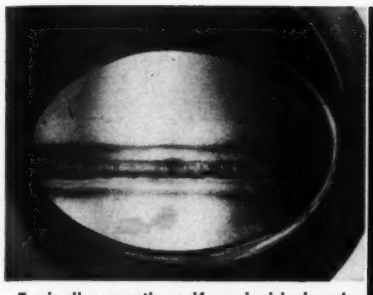
It is perhaps inevitable that myths and misconceptions should spring up concerning the national debt. For example, a common misconception arises from comparing the national debt to the debt of an individual or to that of a private business. The analogy is not accurate. The government constitutes a taxing authority. A private individual or private business does not. The government gets funds for interest payments, on the one hand, by taxing. It returns these sums, on the other hand, to those holding the government debt. In one sense, the debt and the resulting interest payments are what the people of a nation owe to themselves. Only an external government debt (to other nations) bears some relation to a private debt.

The burden of the national debt, however, is not immediately self-evident. It is not what people think it is. Assume for the moment that the debt is not repaid. Each year the government must meet the interest obligation, an item currently amounting to about 2½ percent of our national income. Perhaps no direct burden is involved, for the money taken from one pocket as taxes goes into another as interest received. But the pockets in question may be in different people's pants.

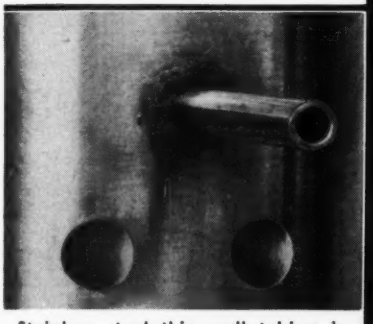
Robin Hood Reversed

While statistical evidence is weak, it appears that the people who receive most bond interest are not those in low-income brackets. Insofar as this situation holds true, interest constitutes a regressive element in our fiscal system—Robin Hood in reverse. This type of redistribution of income tends to reduce purchasing power and becomes a depressive element in times of less-than-full employment although it is a favorable element in times of threatened inflation.

A more important burden is the effect on the taxpayer of the larger taxes necessary to pay the

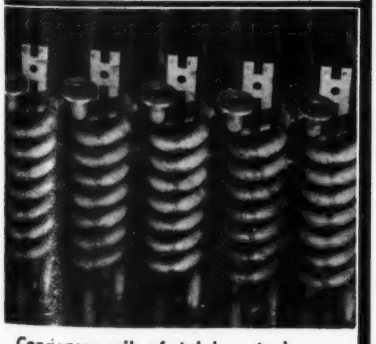


Typically smooth, uniform inside bead in stainless steel piping which results from making root pass with PP&E "free flow" inert gas shielded tungsten arc-welding process.

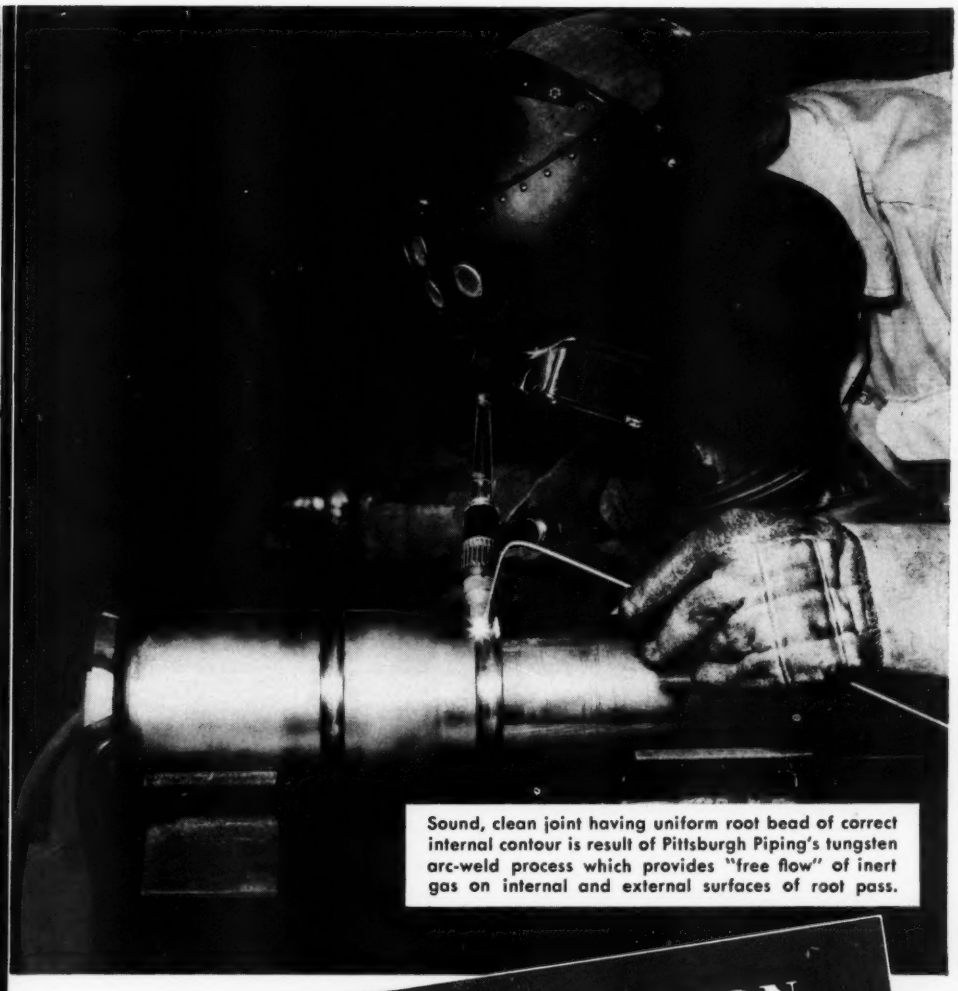


Stainless steel thin wall tubing is soundly welded to heavy stainless steel body by a skillful PP&E inert gas tungsten arc-welder.

Smooth external surfaces of welds on this component are the result of long experience in welding stainless steels.



Condenser coils of stainless steel, completely prefabricated at Pittsburgh Piping and Equipment Company.



Sound, clean joint having uniform root bead of correct internal contour is result of Pittsburgh Piping's tungsten arc-weld process which provides "free flow" of inert gas on internal and external surfaces of root pass.

EXPERT FABRICATION of Stainless Piping FOR POWER OR PROCESS

At PP&E we have been fabricating stainless steel piping since the middle 1920's . . . extended experience which is unsurpassed by any other power piping fabricator. The importance of this experience, to you, is its great value in avoiding errors in omission and commission which can result in inefficiency, damage to expensive equipment, and dangerous operating conditions. Consult our nearest representative for further information.

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AND EQUIPMENT COMPANY
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Steam Generators

This famous power package is shop-assembled, shipped complete with all components installed, and occupies a minimum of space in the plant. You couldn't ask for a more efficient, dependable and simple-to-operate unit—as you'll agree when we give you the details! Let us have your requirements, without obligation.

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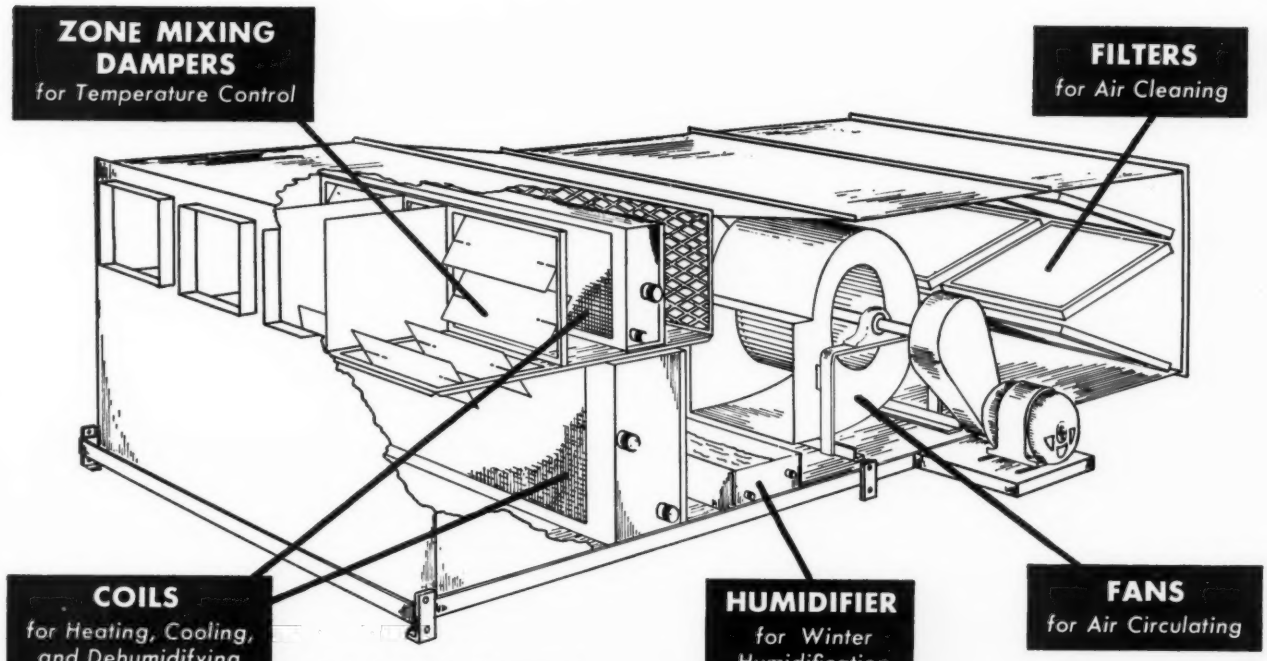
interest. Taxation always has some distorting effects on economic behavior although the effects are not always easy to detect. Centuries ago England placed a tax on windows. People then built dark houses — even though the government ultimately collected the same amount of revenue on the smaller number of windows by raising the tax rate. Similarly, raising the income tax rate does not increase revenues if people decide that extra income is not worth working for.

Even more important, high corporation taxes and high personal income taxes often deter individuals from venturing their capital on risky enterprises where the chances of profit and of failure are high. Instead, they may prefer safer investment in government bonds. The result is less technological progress and lower national income.

Future and the Debt

Of the five major wars in which we have been engaged, each has been characterized by a debt dwarfing the previously existing debt. Four times, the aftermath of the enormously expanded debt and the accompanying inflation has been felt in terms of economic adversity, deflation, and depression. Of vital interest to the consulting engineer is the answer to this $64 question—what will happen the fifth time?

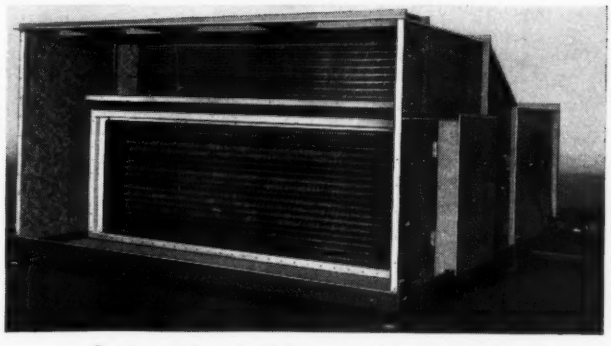
Whether we will continue to have prosperity or will sink into a depression depends in some measure on still another issue—how the debt is managed. With a debt of the present size, there arise recurring questions as to types of bonds to be issued, the amount of revenue to be set aside for debt liquidation, and similar problems. Debt management has become increasingly important as an instrument of government economic policy. We may expect that in the years to come decisions as to debt management will be strongly colored by the condition of the whole economy. ▲▲



Typical 4-zone unit arranged for complete conditioning.

Different needs simultaneously in different areas . . . yet handled by this one unit

ZONE CONTROL AIR CONDITIONING



Front panel and mixing dampers removed to show arrangement of heating and cooling coils.

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Clarage Blow-Thru Multitherms are units that take variables in stride! A separate set of mixing dampers for each zone permits proper "balancing" of conditioned air according to the loads imposed by sun effect, wind, occupancy, and other factors.

Thus, in a building of medium size, a single unit provides uniform air conditioning results with far greater economy and simplicity than possible with previous arrangements of equipment. Certainly the Blow-Thru Multitherm is a unit to investigate thoroughly for any application where simultaneously unequal loads are encountered.

A request for Bulletin 1310-A will place in your hands capacities, dimensions, and other descriptive details of Clarage Blow-Thru Multitherms. CLARAGE FAN COMPANY, Kalamazoo, Michigan.

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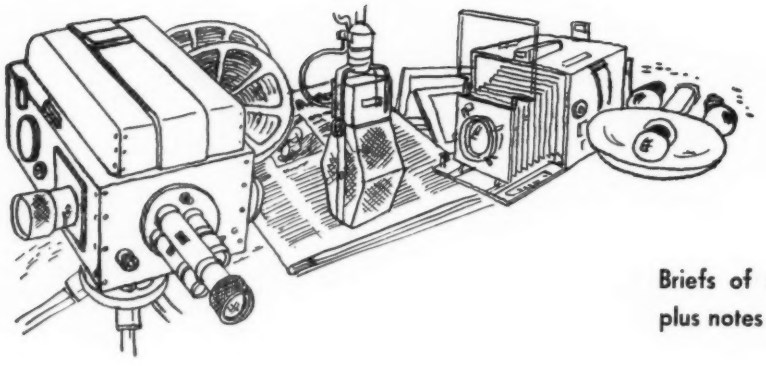


NEWS

Briefs of current interest to the consulting profession plus notes on new equipment in the field of engineering

Titanium Industry Reviews Its 1954 Progress

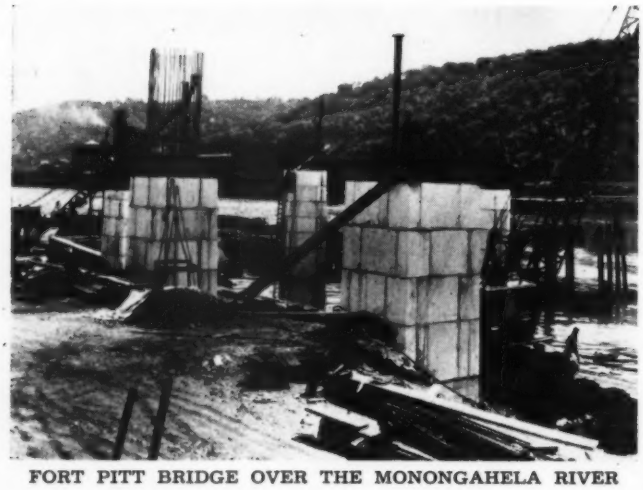
Producers and processors of metallic titanium in 1954 scored encouraging gains: production of basic metal more than doubled the 1953 figure; quality was improved; and processing losses were reduced. (See "Coming Role of Titanium," CE, May, '54.)

Each of the two commercial producers of raw titanium sponge, Titanium Metals Corp. of America and E. I. du Pont de Nemours, reached 10 tons-per-day capacity production by late summer. Compared with a 1953 output of 2250 net tons, total 1954 sponge production is estimated by government agencies at 5250 tons, of which TMCA and du Pont contributed about 2500 tons each, the Bureau of Mines added 150 tons, and other pilot units made up the remainder. Imports from Japan followed a rapidly rising curve by mid-summer, the year's total being 250 tons, the major portion of quality metal originating in the Toho Titanium Co. plant at Chiagasaki City, Japan, a Mitsui enterprise.

The year was marked by substantial price markdowns. In Feb. TMCA led off with reductions in sheet, strip, and plate which in certain grades and sizes amounted to 12 percent. Lower market prices for bars and billets were set later when Rem-Cru Titanium, Inc. cut its prices for those products by as much as 14 percent. Sponge prices were also reduced during the year, initiated by du Pont. The price of sponge was reduced from $5.00 to $4.72 per lb on April 1, and to $4.50 on Dec. 1.

For the past five years titanium sponge production has at least doubled each year and conservative estimates predict about 8800 tons in 1955, with the possibility of 15,200 tons in 1956, and 22,500 tons in 1957. The only new facility certain to contribute significant quantities of metal in 1955 will be Cramet, Inc., a Crane Co. subsidiary, which is constructing a 6000-ton-per-yr plant at Chattanooga, Tenn., under a contractual arrangement with the General Services Administration. The Dow Chemical Co. plant, Midland, Mich., under GSA contract for 1800 tons annually, probably will come in with pilot quantities during 1955, but likely won't approach capacity operation until late 1956.

One of the most significant new entries into the production field in 1954 was the Electro Metallurgical Co., a division of Union Carbide & Carbon Corp.,



FORT PITT BRIDGE OVER THE MONONGAHELA RIVER

Bridge drain lines of eight inch wrought iron pipe are being built into piers of the Fort Pitt Bridge which will span the Monongahela River at Pittsburgh's Golden Triangle as part of the Penn-Lincoln Parkway linking the city's suburbs. A. M. Byers Co. furnished the corrosion-resistant pipe.

RICHMOND-SAN RAFAEL BRIDGE ON SAN FRANCISCO BAY

Aluminum erection-truss unit is placed between two towers to serve as scaffold-like falsework in erection of permanent steel spans on the Richmond-San Rafael Bridge over San Francisco Bay. Aluminum alloy shapes and plates for trusses were furnished by the Aluminum Company of America.

MR. CONSULTING ENGINEER:

There's a Low-Cost System to STOP THAT DUST!

Here's just one example of how Johnson-March stops dust right at its source. The Johnson-March system is turned off at this point where coal is discharged from a chute onto a conveyor belt in a power plant. Compare this unretouched photo with the one below.

This unretouched photo shows the Johnson-March system operating at the same discharge point. Note absence of dust. These systems are proving themselves in hundreds of plants.

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Titanium Progress

—Starts on page 58

which late in the year completed negotiations with the government for a 7500-ton-per-year plant at Ashtabula, Ohio, and has announced late 1957 as its target for full production. Horizons Titanium Corp. is building a small electrolytic pilot unit at Stanford, Conn., under a government research contract; Kennecott Copper Corp. has announced the likelihood of a 3-ton-per-day semi-commercial plant; and there are rumors that Britain's Imperial Chemical Industries (which is constructing a 1500-ton-per-year plant in England) intends to construct a facility in the United States, possibly in affiliation with a yet unnamed American company.

On the technological front, no new or particularly significant technique for producing the basic sponge metal has made its appearance. Both the Electro Metallurgical Co. and Imperial Chemical Industries have reverted to a modification of the original method of producing metallic titanium, using sodium to reduce the tetrachloride, as against the magnesium (Kroll) reduction of the tetrachloride as practiced by TMCA, du Pont, and Cramet. The only fully-integrated facility operating or in the planning stage is Titanium Metals Corp. of America, which carries ore through the entire productive sequence to finished mill products, and recycles the by-products of reduction—chlorine and magnesium. In the melting of titanium sponge, the double-melting and vacuum-melting techniques, announced early in the year by TMCA, are becoming standard practice throughout the industry.

Engineers of the High Vacuum Equipment Corp. and the aircraft industry have worked together to develop techniques for annealing titanium parts in high vacuum furnaces. The annealing process removes hydrogen and other unwanted gases to produce parts that are more ductile, have greater fatigue resistance, longer life, and greater strength.

Titanium's high strength with light weight, and superior corrosion resistance prompted the office of the Assistant Secretary of Defense to announce, "We believe that the successful development and engineering application of titanium in this country will represent a major technological break-through. It opens up the possibility of military designs with performance characteristics that would be impossible to attainment with other known materials, and could have an important bearing on the outcome of our technological race."

Engineering Registration Act Shows Its Teeth

The Texas Engineering Registration Act includes the provision that in the construction of a public work involving professional engineering where public health, welfare, and safety is involved, and where the contemplated expenditure for the completed project exceeds $3000, the engineering plans, specifications, and cost estimates must have been prepared by, and the engineering construction must be executed under the direct supervision of, a registered professional engineer authorized to practice professional engineering under provision of the Revised Civil Statutes of Texas.

Recently, this law proved to have teeth in it. The Fort Bend County Drainage District had engineering plans, specifications, and cost estimates drawn up for "Proposed Improvements—Big Creek Watershed." A contract for the improvement was awarded in the amount of $240,000 and work begun on the project. In December, the Texas Society of Professional Engineers instituted court proceedings because the plans, specifications, and cost estimates had not been prepared by a PE, nor was the construction under supervision of a PE.

The Court ordered the Drainage District to have a registered PE of its choice review, and if necessary, revise and modify plans, specifications, and estimates, and certify that the resulting data are the same as those which the PE would have prepared himself. The same engineer will also supervise construction.

Columbia Development Project Will Parallel TVA

The Cauca Valley is one of Columbia's most important agricultural areas and one of the most densely populated. Since its large coal reserves, hydro-electric power potential, and rich agricultural lands offer promising opportunities for intensive development, the government of Columbia, under recommendation by David E. Lilienthal, former chairman of TVA, has created the Autonomous Regional Corporation of Cauca as a first step toward development of resources by regional agencies.

The Corporation, which will have functions analogous to those of the Tennessee Valley Authority, has retained three engineering firms to assist it in its work and has appointed William Hayes, former assistant manager of TVA, as technical advisor.

Headed by Dr. Diego Garces as chairman, the group is now drawing up a program for better use and control of the waters of the Cauca River, for the adoption of modern methods and techniques in land use and in exploitation of mineral resources, and for better transportation. The Corporation work in the Cauca Valley will serve as a demonstration and training area for the country as a whole.

The three engineering firms retained, Olarte, Ospina, Arias & Payan, Ltda., Gibbs & Hill, Inc., and Knappen-Tippetts-Abbett-McCarthy, will train engineering personnel of the Corporation and assist in organization of its engineering department. Other work to be done by the firms will cover power development and utilization, including thermal projects, flood control, irrigation, drainage, and subjects related to these principal purposes.

The World Bank will assist the Corporation in formulating plans for all phases of the development

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Columbia Development Project

—Starts on page 60

program with particular emphasis on the financial and economic aspects. The Bank mission, which will visit Columbia next month, will be headed by Dr. Harold W. Larsen, economic adviser to the Bank's Department of Operations for the Western Hemisphere. Other staff members of the mission will be Torgeir Finsaas, transportation adviser, and Douwe Groenveld, agricultural economist. Outside consultants retained by the Bank to serve on the mission are Juan Bazo (Peru), adviser on agricultural production, and James L. Kunen (U.S.), advisor on resources development.

Rubber Railroad Crossing Under Test in Akron

The standard wooden railroad crossing is an irritation to the motorist and a maintenance headache to the railroad. A solution to this problem — a rubber railroad crossing — is under test on the main track of the Erie Railroad in Akron, Ohio.

The rubber vehicular roadway between the tracks is built with slabs of rubber 36 in. wide x 59 in. long. They are a little more than three inches thick, including a sheet of heavy gauge steel sandwiched

SLABS REST ON WOOD PLANKING LAID OVER CROSSTIES.

within each slab. The rubber roadway rests on heavy treated wood planking, called risers, laid on top of each regular railroad tie. Each slab is fastened down by lag screws 12 in. long, installed through metal and rubber grommets to hold the slabs securely in place.

The rubber slabs are designed with tapered flanges where they meet the rails. When sprung into place, the rubber flanges form a watertight wedge to the rail, thus preventing seepage which causes deterioration of ties and fouls ballast in the crossing. Under normal conditions, the rubber installation should last indefinitely, according to engineers.

Smaller rubber slabs were used outside of the rails, extending to the tie ends of the track and these, too, form a watertight union with the rails.

The rubber slabs were molded, complete with their metal reinforcing, in the Goodyear industrial rubber products plant at St. Marys, Ohio.

AICE Panel Members Appraise FOA Engineering Projects

The essential requirement for success of U.S. Government engineering projects abroad is the concentration of full responsibility for engineering design and construction supervision, for each project, in a single, competent engineering organization. This was the recurring theme presented to the American Institute of Consulting Engineers at the annual meeting in New York City on Feb. 2. Four AICE members presented an appraisal — based on personal observations — of the success of the Foreign Operations Administration's program involving engineering. The panel members — Maurice Scharff, Franklin J. Leerburger, Burnside R. Value, and William Ginsberg — had formed part of an engineering-investigating team sent abroad by FOA.

As reported at the AICE meeting, the FOA program was found to be a great over-all success, with some unfortunate exceptions. The successful projects were found to have been in the responsible charge of a single engineering organization, whereas those that were less than successful suffered from lack of such unified responsibility. Perhaps the universal fault found by the investigating team was inadequate record keeping, from which followed lack of control, and lack of knowledge about progress and effectiveness of projects.

Speaker for the March monthly meeting, to be held March 2 at the Engineers' Club, New York City, will be John M. Convery, of the National Association of Manufacturers, speaking on "Employee Relations and the Consulting Engineer."

Daylight Photocopy Process Aids in Patent Work

Consulting engineers must have up-to-date information on patents relating to projects they are working on. But patents include much information superfluous to the needs of the engineer, and condensation of the text is time consuming.

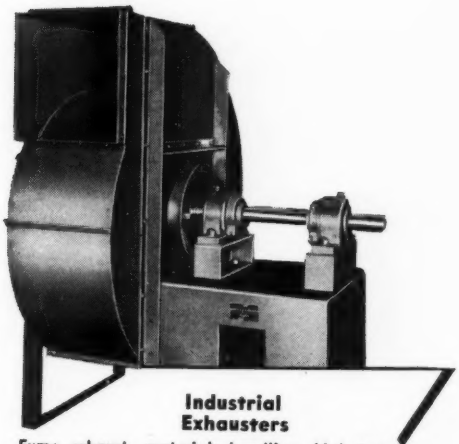
The solution is to photocopy the original patent. From this copy, pertinent portions of the text and drawings can be clipped and pasted on another sheet of paper. After any additional information necessary is typed on paper, completed page is photocopied.

Photocopies of this sort can be made under daylight conditions in less than a minute for about ten cents each on dry-transfer process photocopy equipment such as the Dri-Stat made by Peerless Photo Products, Inc. "Bright-Light" No. 1 (negative) paper coated with a slow-speed emulsion reduces the possibility of pre-exposure and allows the operator time for a careful job. A flat-bed printer can be used for copying from thick bound volumes.

Bayley

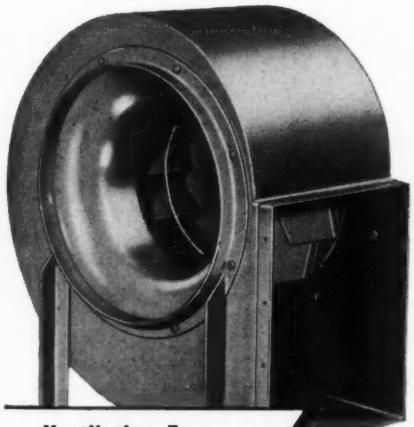
Engineered

AIR HANDLING EQUIPMENT



Industrial Exhausters

Fume exhaust, materials handling, high temperatures effectively handled with this radial-blade fan.



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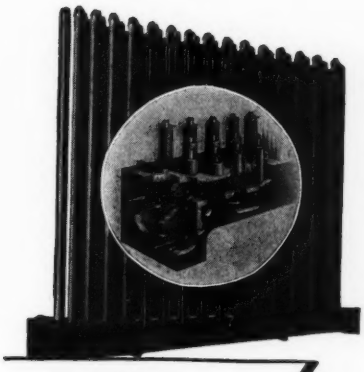
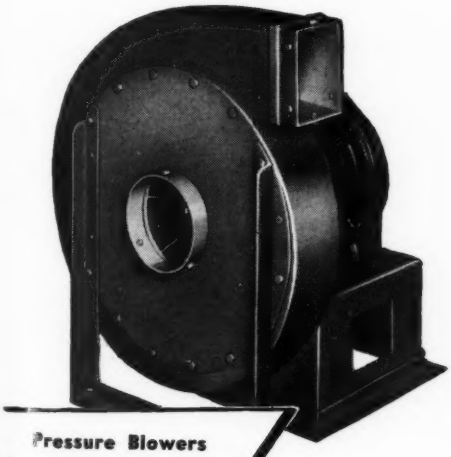


Heaters

Blast Coils—Aerofin & Chinook; Heating and Cooling; Steam, Water, Direct Expansion.



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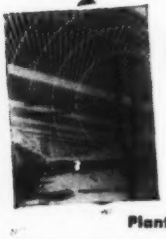

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MEN IN ENGINEERING

★ Henry A. Jandl, associate professor of architecture at Princeton University, has been retained as architectural consultant by United States Steel Homes, Inc., the housing subsidiary of U. S. Steel Corp.

☆ The Austin Co. has promoted four of its engineers to the office of vice president: Philip K. Davis; John N. Beckley, who also becomes eastern district manager; Clayton L. Foster, who becomes manager of The Special Devices Div.; and John H. McVey, who is also district manager in southern California.

★ Soil Testing Services, Inc. has added Clyde N. Baker, Jr. to its staff. Baker was formerly research assistant at the Massachusetts Institute of Technology soil stabilization laboratory.

★ Bernard P. Thomas is named director of the Highway Construction and Materials Dept. at Dow Chemical Company's Midland Div. The new department will be concerned with developing new uses in the highway and construction field for calcium chloride, magnesium oxide, and other Dow products.

★ The F. Paul Anderson Medal, highest award of the American Society of Heating and Ventilating Engineers, has been awarded to Charles S. Leopold, Philadelphia heating and air conditioning consulting engineer for his contributions to the advancement of human comfort in the fields of heating and ventilating.

★ Dr. Charles H. Lutz is resigning his position as a staff member of Designers for Industry, Inc. to form a new company, Atomic Energy for Industry, Inc., with headquarters in Cleveland. Dr. Lutz will remain affiliated with DFI as a special consultant and associate staff member. The new company will concentrate on the commercial and industrial applications of atomic energy.

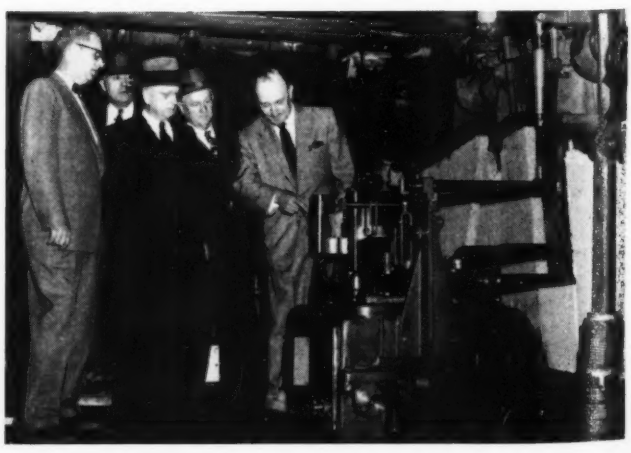
★ Six staff members of Cresap, McCormick and Paget have been elected principal associates of the management consulting firm: Robert G. Baumann, Erwin J. Bofferding, William S. Callander, Henry Keyserling, Edison Montgomery, and John G. Steinle.

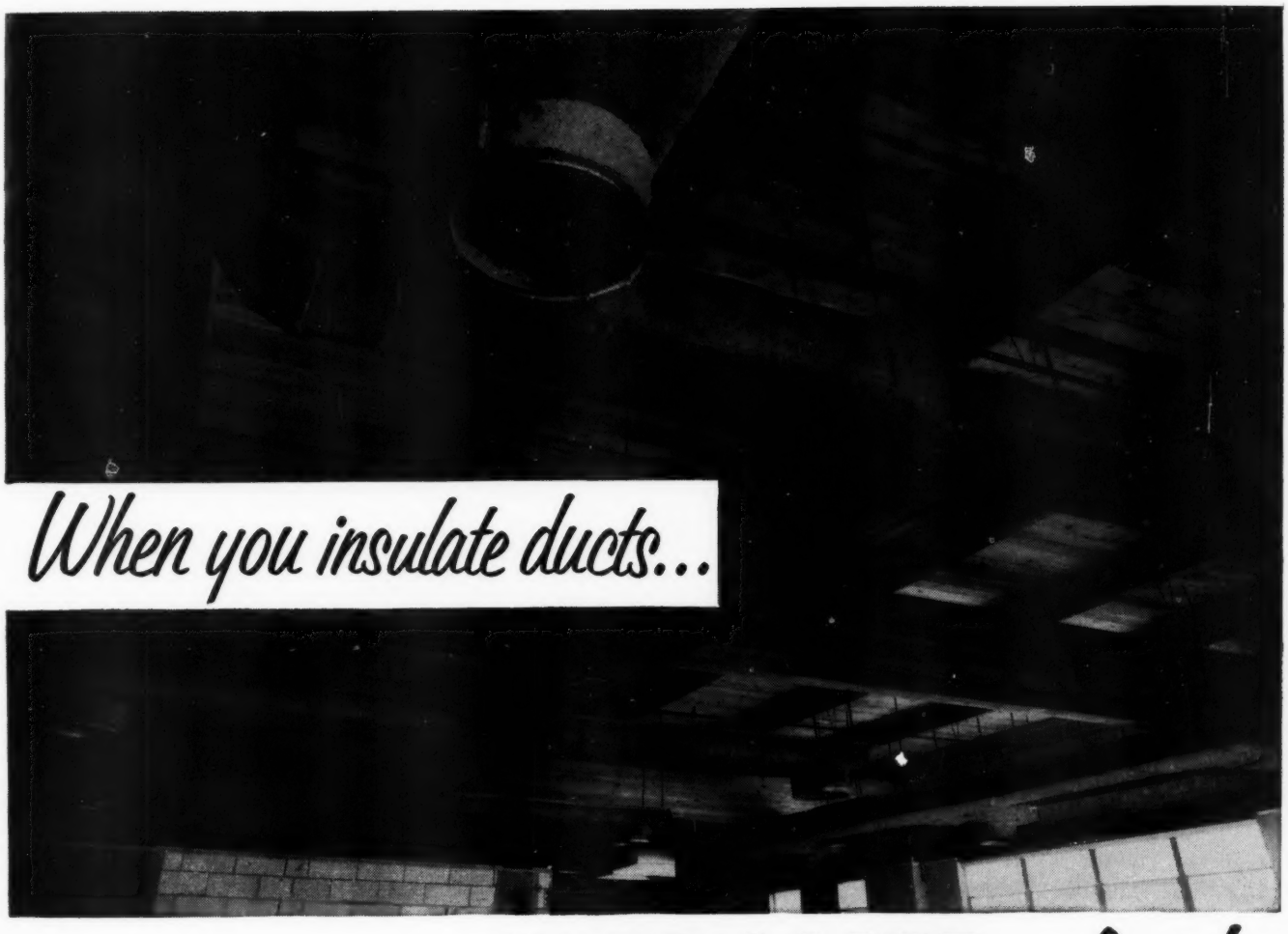
★ Thomas J. Kehoe, formerly a senior associate with Pomeroy and Associates, consulting engineers of Pasadena, Calif., has joined Beckman Instruments, Inc. as application engineer.

★ Dr. Samuel G. Hibben, former director of applied lighting for the

TEST GENERATOR

Witnessing the test of an 11,500 kw turbine generator for the city of Kinston, N. C. are, L. to R.: W. G. McAdams, director of utilities Kinston Plant; L. E. Hammer, Worthington's Wellsville Works; Wm. C. Olsen of William C. Olsen & Assoc.; Albert Scott, chief operating engineer of Kinston; A. F. Reinking, manager of Turbine Sales, Worthington.





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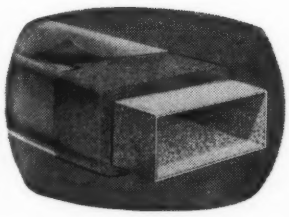

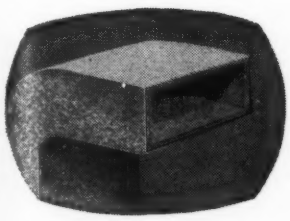

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first flexible duct insulation of fine glass fibers available with factory-applied vapor barrier. Ultralite is still available plain or with a wide choice of facings — some for appearance, some as vapor barriers.

first flexible glass fiber insulation to spring back to full original thickness every time after being compressed!

first flexible duct liner of fine glass fibers. Recent examinations of Ultralite Duct Liner installed 7 years ago show no indications of air erosion.

first flexible duct liner on the market with spray coating (1948).

first flexible glass fiber insulation available nationwide at convenient stocking points for immediate delivery. And ULTRALITE is still available *more* readily, in *more* cities, than any other glass fiber insulation!

Ultralite distributors are listed in the Yellow Pages in 57 Cities.

GUSTIN-BACON *Manufacturing Company* gb

Molded glass fiber pipe insulation • Pipe couplings and fittings • Thermal and acoustical insulations

212 W. 10th St. **Kansas City, Mo.**

You'll find your fan in the complete "Buffalo" line!

"Buffalo" builds *anything* and *everything* you need in the fan and blower line. Big ventilating fans in our standard sizes deliver up to one half million cubic feet per minute, and more if required for special applications.

The smallest "Buffalo" Breezo Propeller Fan delivers as little as 500 cubic feet per minute and fans of this type range in size up to 144" diameter.

In between these two are Industrial Exhausters—Pressure Blowers —Mechanical Draft Fans—Electric Blowers—Exhausters—Axial Flow Fans — Belted Vent Sets — Baby Vent Fans — HVA Heating and Ventilating Units — all built to the high standards of the famous "Q" Factor* which has given "Buffalo" users more for their money for 78 years.

Write us about your air needs. You need look no further than "Buffalo" for the best solution.

**The "Q" Factor — the built-in Quality which provides trouble-free satisfaction and long life.*

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Publishers of "FAN ENGINEERING" Handbook

Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

Sales Representatives in all Principal Cities

VENTILATING AIR CLEANING AIR TEMPERING INDUCED DRAFT EXHAUSTING
FORCED DRAFT COOLING HEATING PRESSURE BLOWING

MEN

—Starts on page 64

lamp division of Westinghouse Electric Corp., and a past president of the Illuminating Engineering Society, is retiring from Westinghouse after almost 40 years of service.

★ Henning de Bang is appointed chief engineer for the Design Development and Engineering Div. of the Baltimore, Md. branch of the Marietta Concrete Corp. He was formerly associated with Ford, Bacon and Davis, Inc., consulting engineers of New York City.

★ A new department has been formed in Babcock & Wilcox Company's Boiler Div. to consolidate the contract and erection phases of the division's operations. The department, to be known as Contract and Erection, will be headed by Lawrence W. Hayward as manager. R. W. Fox and J. P. Craven will continue as contract manager and erection superintendent respectively.

HAGLUND CUTLER

★ The H. K. Ferguson Co. announces appointment of Robert R. Cutler as vice president and central district manager. C. J. Haglund is also named vice president and manager of the western district office in San Francisco.

★ Carl George Arthur Rosen, consulting engineer to the president of Caterpillar Tractor Co., and Lecturer on the faculty of Stanford University, is elected 1955 president of the Society of Automotive Engineers. He succeeds William Littlewood, vp of American Airlines, Inc.

★ Dr. D. B. Steinman and his family have established the David B. Steinman Foundation, Inc. for the purpose of making contributions and grants to educational institutions and other worthy causes. Principal objective is to make gifts to engineering schools for establishing scholarships, awards, and loans.

★ H. Everett Woodruff, vice president in charge of the investment department of the New York Life Insurance Co., has been elected to the board of directors of Gibbs & Hill, Inc.

IS YOUR REPUTATION AT STAKE ON THIS JOB?

Make-shift or hit and miss piping systems are not only costly in corrections and repairs . . . but certainly reflect on the ability of the mechanical engineer. It is *not* necessary to gamble on an efficient, long lasting insulated piping system. RIC-WIL's forty-five years in the Insulated Piping Field is your assurance of the finest piping system for both overhead and underground use. Specify RIC-WIL and be sure of the results. For complete technical information contact your nearest RIC-WIL field representative or send for the RIC-WIL catalog.

Quality Piping Systems of the . . .
. . . Highest Thermal Efficiency

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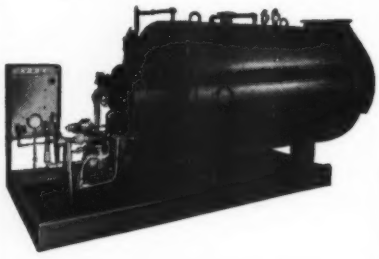
PREFABRICATED **INSULATED PIPING SYSTEMS**

BARBERTON, OHIO



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STEAM BOILERS.

Completely Equipped and Tested at factory.

Fully Automatic for Gas or Heavy Oil or Combination Oil and Gas.

60 to 600 Horsepower. High and Low pressure. A.S.M.E. Code and Nat'l Board.

Efficiency and Capacity guaranteed.

Underwriter's Laboratory and Factory Mutual approved.

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FERRYSBURG, MICHIGAN

Established 1864

FOR REPLACEMENTS ORDER HIGH PRESSURE

GAGE GLASSES

MASTER STANDARD RED LINE & CLEAR *Up to 500 lbs.*

MASTER CLEAR & RED LINE EXTRA STRONG *Up to 600 lbs.*

Made in Lengths up to 144" Long And Outside Diameters ⅜", ½", ⅝", ¾", ⅞", 1", 1¼", 1½".

High Pressure Composition

ERNST RUBBER GASKETS

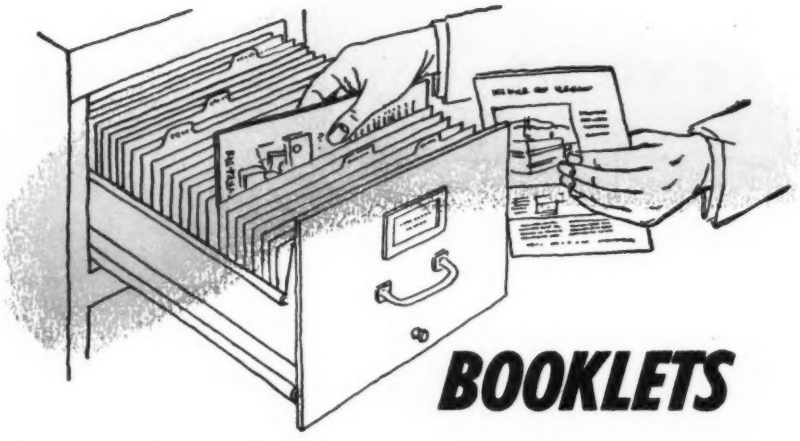
All sizes to fit your gages and valves

FIG. 21—Lip Mold

FIG. 22—Standard

ERNST WATER COLUMN & GAGE CO.

Send for Catalog LIVINGSTON, N. J.



BOOKLETS

Personal copies of booklets can be obtained by writing directly to the manufacturers

"HOT PROCESS WATER SOFTENERS," seven-page booklet 801, includes data on hot process softeners and hot zeolite softeners. Flow diagrams, installation photos, and descriptions of each component of the systems are included. *American Water Softener Co., Inc., Dept. CE, 4th and Lehigh Ave., Philadelphia 33, Pa.*

"STOP AIR POLLUTION WITH THE LIQUID PRECIPITATOR MULTIPLE-ACTION SCRUBBER," four-page booklet LH12054, tells how to control dusts discharged from stacks of cyclones, rotary dryers, kilns, roasters, mixers, pulverizers, and sintering plants. Operating principles are explained in detail. *Johnson-March Corp., Dept. CE, 1724 Chestnut St., Philadelphia 3, Pa.*

HOW TO CONTROL CORROSION with stainless tubing and pipe is explained in 28-page catalog T. D. 113. Main types of corrosion are described along with a breakdown of basic types of applications for stainless tubing and piping in anti-corrosion service. Helpful information is given on selection, and specific alloys suggested for varying conditions. *Carpenter Steel Co., Alloy Tube Division, Dept. CE, Union, N. J.*

"FLUORESCENT LAMPS AND AUXILIARY EQUIPMENTS," eight-page technical bulletin LS-101, gives complete data on the Circline, General Line, Slimline, and Rapid Start lamps. Wiring diagrams, equipment for each type of lamp, and equipment for suppression of radio interference are given. *Application Engineering Dept., Lamp Div., General Electric Co., Dept. CE, Cleveland 12, Ohio.*

"L&N pH CONTROL OF COOLING TOWER WATER," four-page data sheet 700 (1), offers suggestions on measurement and control of the pH of cooling tower water, and describes equipment for this application. How pH control can conserve make-up water, protect wood, prevent scale, and minimize slime is explained. *Leeds & Northrup Co., Dept. CE, 444 North 16th St., Philadelphia 30.*

MALLEABLE PIPE COUPLING AND FITTINGS for petroleum, mining, sprinkler systems, and general industrial use are shown in 16-page folder CF1054-10. Photographs demonstrate savings in time and labor made possible by use of Rolagrip couplings for plain end pipe, and Gruvagrip and Gruvajoint couplings for grooved pipe. *Gustin-Bacon Mfg. Co., Dept. CE, 210 W. Tenth St., Kansas City 6, Mo.*

"DOORS FOR INDUSTRY AND AVIATION," 15-page bulletin, provides up-to-date facts, figures, and planning data on new developments in doors for hangers, warehouses, piers, and other buildings. *Marketing Services Div., International Steel Co., Dept. CE, Evansville, Ind.*

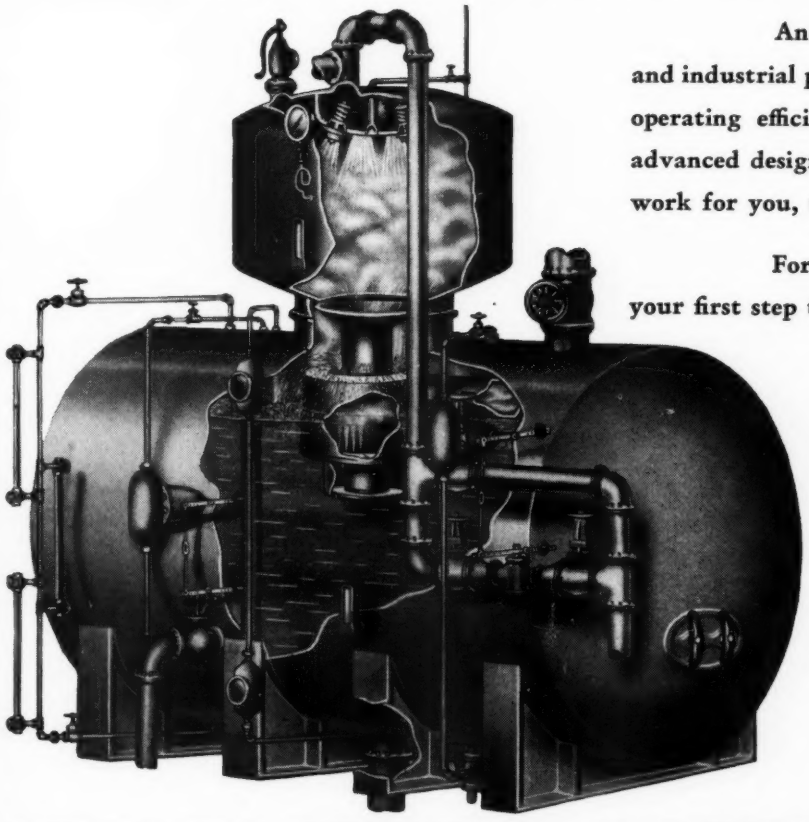
"A FINISHED STRUCTURAL WALL IN ONE OPERATION WITH MARBLOX CONCRETE MASONRY," a four-page folder, describes conventional concrete masonry units that embody a dense concrete surface mix to give one or both of their exposed surfaces a smooth, colorful texture. Colored photographs show the material in use in a school, boiler room, and recreation room. *Marble Face Blocks, Inc., Michigan Ave., Dept. CE, Kenilworth, N. J.*

POWER CONNECTORS for use with aluminum and copper conductors for every application are listed in this catalog. Included is a data section to assist in estimating, planning, and engineering. *Delta-Star Electric Div., H. K. Porter Co., Inc., Dept. CE, 2437 Fulton, Chicago 12.*

REGENERATIVE TURBINE PUMPS, designed for boiler feed service with boilers up to 1000 hp, operating at pressures up to 300 psi, are described in 12-page bulletin 107.

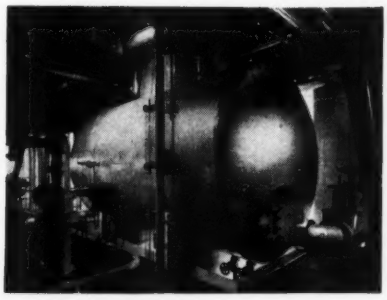
In Deaeration, too

BELCO Builds a Complete Line-

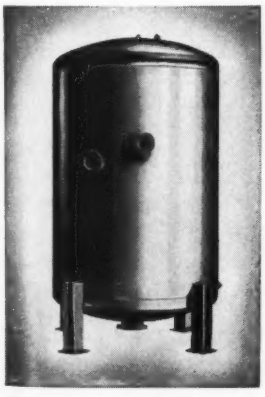


An increasing number of well known utility and industrial plants are using Belco equipment to increase operating efficiency and decrease operating costs. Belco advanced design and application experience can be put to work for you, too.

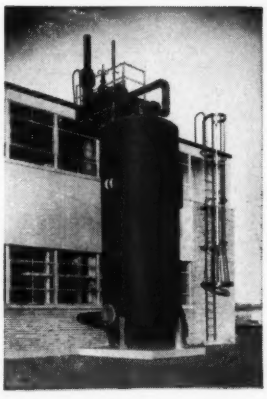
For technical assistance write or call Belco — your first step to lower costs.



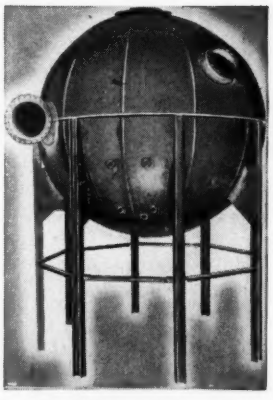
SPRAY TYPE — Belco Deaerator in large eastern oil refinery. Has a capacity of 300,000 lbs/hr.



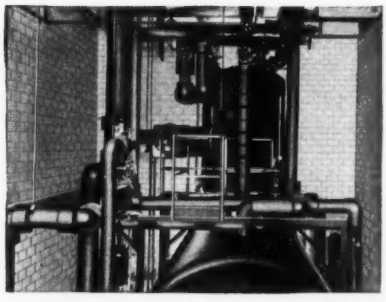
MARINE TYPE—Typical Belco marine heater furnished to shipyards. (Approved by Lloyds of London)



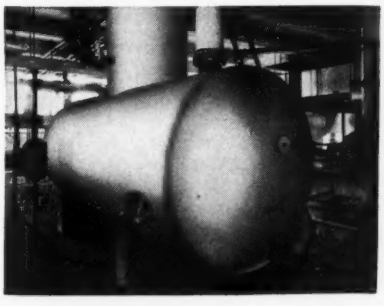
OPEN TYPE—Deaerator at large eastern pharmaceutical plant. Capacity of 80,000 lbs/hr.



VACUUM TYPE — Unit shipped set-up to midwestern utility. Has 150,000 lbs/hr capacity.



SPRAY TRAY TYPE — Belco Deaerator at New York State institution boiler house. Capacity 120,000 lbs/hr.



TRAY TYPE — Belco Deaerator at southern municipality. Has a capacity of 125,000 lbs/hr.

Belco

Boiler Feedwater Heaters • *Water Softeners* • *Filters* • *Clarators*
Demineralizers • *Automatic Process Control Panels*

BELCO INDUSTRIAL EQUIPMENT DIVISION, INC.
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REGIONAL OFFICES: *Philadelphia, Pa., Chicago, Ill., Houston, Texas*
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BELCO DESIGNS, ENGINEERS & FABRICATES WATER PROCESSING EQUIPMENT

BOOKLETS —Starts on page 68

Complete specification information is included along with photographs, cross sections, and drawings of pumps. *Roy E. Roth Co., Dept. CE, 2420 4th Ave., Rock Island, Ill.*

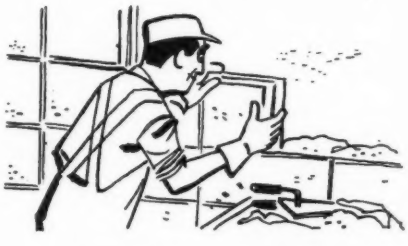
"ALCOA ALUMINUM IN ARCHITECTURE" contains a vast store of information on the use of aluminum in this fast expanding field. Basic types of aluminum finishes, exterior surfaces, and specification charts are included. Resistance of aluminum to weathering in sea coast and industrial atmospheres is discussed. *Aluminum Company of America, Dept. CE, 754 Alcoa Building, Pittsburgh 19, Pa.*

"RELAY SELECTION TABULATIONS," two-page bulletin 553, includes easy-to-read charts of help in specifying magnetically or mechanically held relays. Circuit diagrams are given for both types of relays. *Automatic Switch Co., Dept. CE, 391 Lakeside Ave., Orange, N. J.*

OVERHEAD TYPE DOORS, electric operators, and radio control for industrial, commercial, and residential applications are fully discussed in 15-page catalog F4644-5. Methods of preparing building openings and space required for installation of an OVERdoor are given in drawings and charts for all models. *Barber-Colman Co., Dept. CE, Rockford, Ill.*

DISTRIBUTION AND LIGHTING PANELBOARDS—their application and features—are discussed in this package of nine descriptive bulletins. Each bulletin includes ratings, dimensions, specifications, and engineering data important to the proper selection and application of this equipment. *Advertising & Sales Promotion, Distribution Assemblies, Dept. CE, General Electric Co., Plainville, Conn.*

MULTIPLE BLOWER TOWER ASSEMBLIES with individual motor drives are described in 11-page bulletin 477. New rating tables give a realistic approach to what can and cannot be done in the way of cooling with these towers, known as the 3-B Series. *C. R. Kranz, Manager, Cooling Equipment Div., Dept. CE, Binks Mfg. Co., 3122 Carroll Ave., Chicago 12, Ill.*

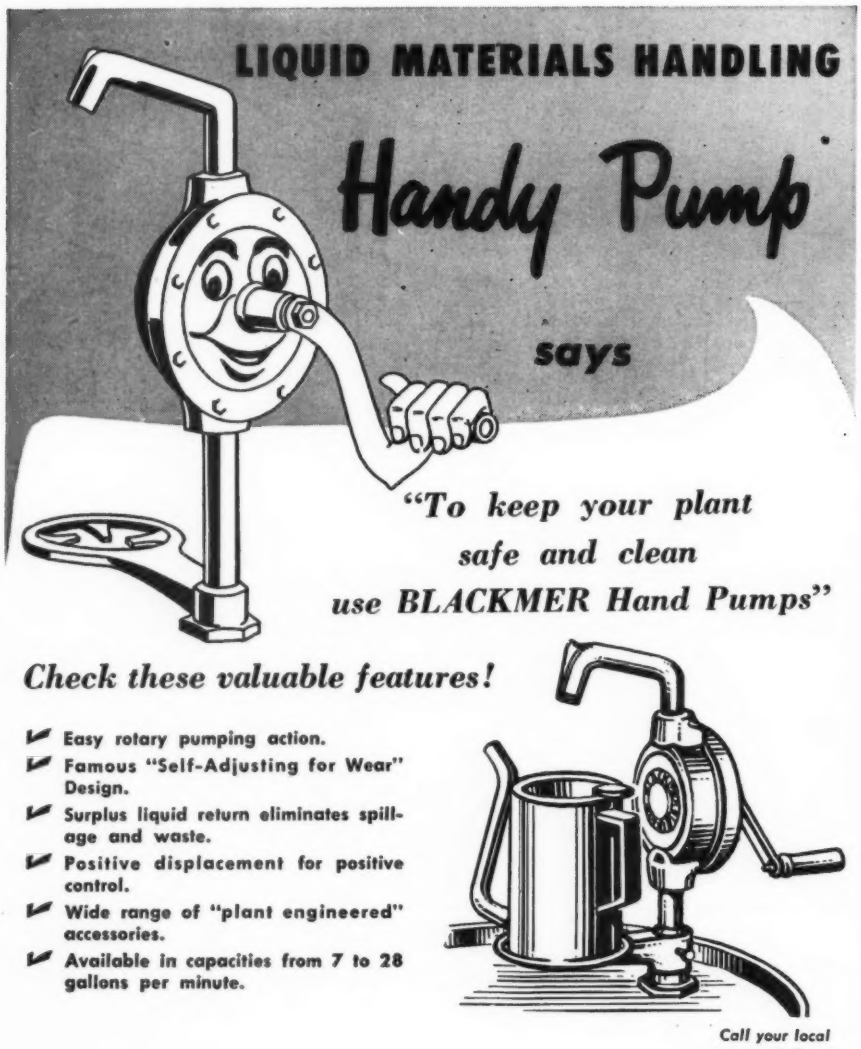


"HOW TO MODERNIZE OLD WINDOWS WITH PC GLASS BLOCKS," seven-page bulletin GB-104, points out that glass blocks have greater insulating value than sash windows, provide better daylighting, and are easier to clean and maintain. Drawings show how glass blocks will fit any existing window opening. *Pittsburgh Corning Corp., Dept. CE, One Gateway Center, Pittsburgh 22, Pa.*

GRATING AND STAIR TREADS—Bulletin 1105, 16 pages, explains important construction features of Tri-Lox interlocked and Tri-Forged welded grating and stair treads. Photographs and detail sketches illustrate styles available and show typical installations. *Dravo Corp., Dept. CE, 1203 Dravo Bldg., Pittsburgh 22, Pa.*

"CONSTRUCTION PLANS NO. 608" presents simple, time saving methods of determining the size, slope, design, and installation of trenches for carrying acids and corrosive liquids. *Corrosion Engineering Products, Dept. CE, Pennsylvania Salt Mfg. Co., 1000 Widener Bldg., Philadelphia 7, Pa.*

DEALKALIZING SALT SPLITTER—Bulletin 4567 discusses the process of chloride anion exchange, why it is



Check these valuable features!

- Easy rotary pumping action.
- Famous "Self-Adjusting for Wear" Design.
- Surplus liquid return eliminates spillage and waste.
- Positive displacement for positive control.
- Wide range of "plant engineered" accessories.
- Available in capacities from 7 to 28 gallons per minute.

Call your local representative or write the factory for information.

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BLACKMER

INDUSTRIAL, HAND AND TRUCK PUMPS, STRAINERS, PRESSURE CONTROL VALVES

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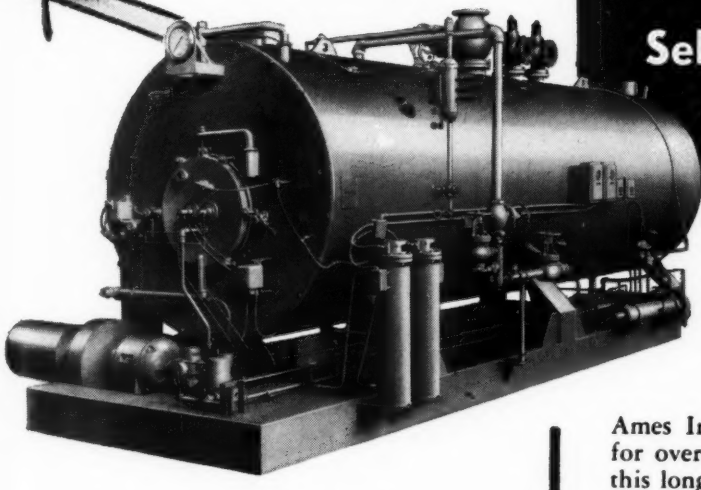
SO YOU HAVE TO BUY A BOILER!

Select an AMESTEAM GENERATOR and solve all your problems



You don't have to dig through mountains of data to pick the boiler that will give your company the most economical and satisfactory service! It's more a question of *where* you buy it than what boiler you choose. What's the maker's reputation?

Ames Iron Works have been building boilers of quality for over 100 years. Back of every Amesteam Generator is this long, successful experience — represented by the Ames Engineering Staff, a large group of skilled boiler makers and an efficient, nation-wide sales and service organization at your disposal. Yes, quality and experience *do* count — and the thousands of Amesteam Generators giving dependable, low-cost service in power, process and heating applications are proof of it. Why not be *sure* by specifying Amesteam Generator? Write today for details and name of your Ames representative.

AMESTEAM GENERATOR

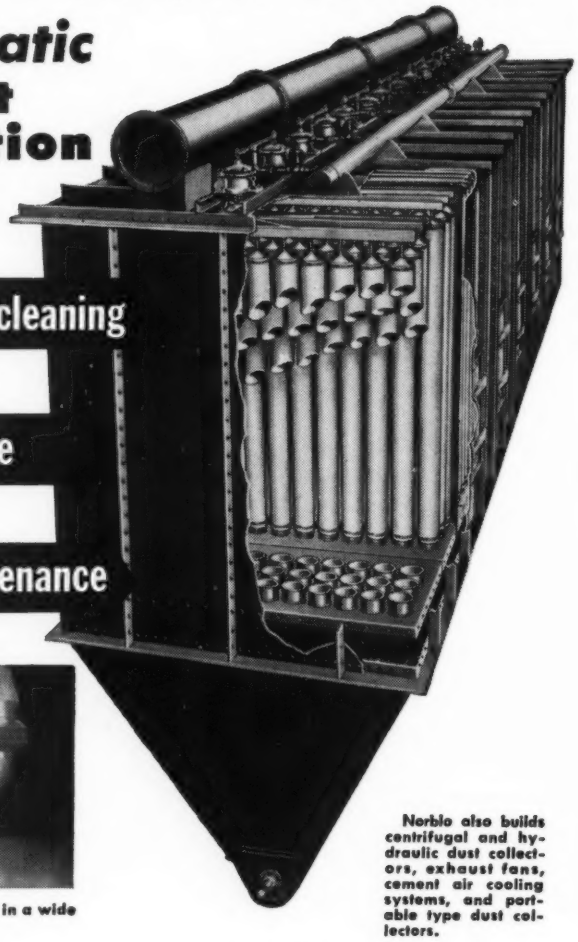
- 80% guaranteed thermal efficiency.
- Single economical package purchase.
- Package installation economy.
- Completely safeguarded.
- Easy, inexpensive maintenance.
- 20 sizes, 10 to 600 H.P., 15 to 200# W.P., oil, gas or oil-gas combinations with quick fuel switchover feature.

AMES IRON WORKS, INC.
BOX P-25, OSWEGO, N. Y.

Install Norblo

to be sure you have worry-free 'round the clock

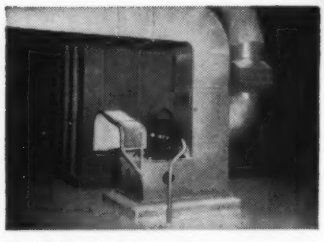
Automatic Dust Collection



Automatic bag cleaning

No down time

Low, easy maintenance

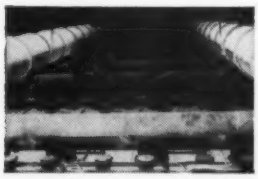


Norblo builds its own blowers in a wide range of capacities.

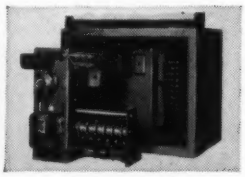
Norblo also builds centrifugal and hydraulic dust collectors, exhaust fans, cement air cooling systems, and portable type dust collectors.

You can have continuous dust and fume collection at full rated capacity without a worry about maintenance down time. Norblo automatic bag type dust arresters handle heavy loads by faithfully maintaining a constant suction drop across the arrester. Compressed air shakers coupled with air reversal action assure efficient bag cleaning, one compartment at a time.

Norblo engineers the complete installation with ample capacity for your needs, with wide adjustability and all the safeguards you may need. Few moving parts combined with a fully coordinated functional design result in very high efficiency, low cost of operation and maintenance. It will pay you to have Norblo engineers study your requirements. Write for Bulletin 164-4.



Each group of 39 bags has its individual compressed air shaker.



The Norblo Variable Electronic Timer governs the shaking and cleaning cycle.

Any compartment may be cut out of the operation and inspected through access door.

The Northern Blower Company

Engineered Dust Collection Systems for All Industries

6426 Barberton Ave. OLympic 1-1300 Cleveland 2, Ohio

BOOKLETS —Starts on page 68

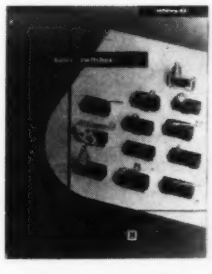
necessary to dealkalize water for boilerfeed and for processing, and shows how water can be dealkalized efficiently and economically with this company's equipment. *Cochrane Corp., Dept. CE, 17th St. and Allegheny Ave., Philadelphia 32, Pa.*

"PROPERTIES OF SUPER REFRACTORIES," 23-page booklet 5056, covers in easy-to-find style the complete line of super refractories made by this company to meet as many different combinations of conditions as possible. Data includes lists of applications together with pertinent charts and tables. *The Carborundum Co., Dept. CE, Refractories Div., Perth Amboy, N. J.*

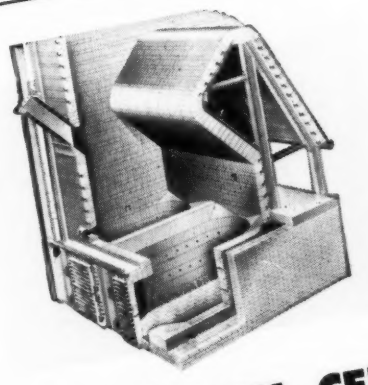
STRAINERS—You can prevent rust, scale, and dirt from clogging steam equipment with use of Yarway fine-screen strainers, according to six-page bulletin S-204. Tables give prices, rates, and dimensions, and woven screen data. Flanged strainers made only to order are described briefly. *Yarnall-Waring Co., Dept. CE, Chestnut Hill, Philadelphia 18.*

"HOW TO SELECT AND USE TODAY'S ELECTRICAL CONNECTORS," nine-page Technical News Letter 24, contains two articles on design of electrical connectors and their efficient application in modernizing industrial plants' electrical distribution systems. *Burndy Engineering Co., Inc., Dept. CE, Norwalk, Conn.*

TO AID THE DESIGN ENGINEER in proper selection of switches for particular requirements, 28-page catalog 62 describes ten classifications of the standard line of Micro Switch phenolic enclosed, precision snap-action basic switches. Basic switches, auxiliary actuators, and terminal enclosures are all covered. *Micro Switch, Dept. CE, Freeport, Ill.*



"MOVEABLE METAL WALLS PROVIDE SPACE CONTROL," 67-page catalog 55, is a detailed study of the ability of these walls to adapt space readily and economically to changing space requirements. Contents are arranged and indexed so that this book can be used as a practical workbook on space control. *The Mills Co., Dept. CE, 998 Wayside Rd., Cleveland 10.*



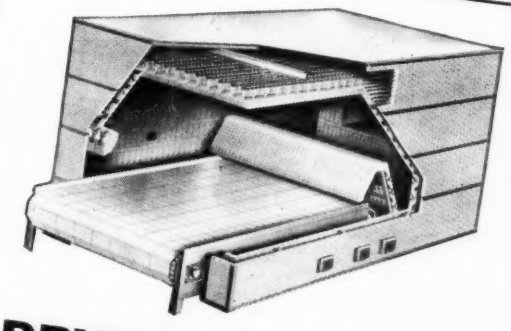
MOIST FUEL CELLS

An important application of B-L unit-suspended walls and arches is found in furnaces where a fuel with a high moisture content is burned. Although designed primarily for use in cane sugar countries for bagasse burning, these furnaces have proven so successful in other fields such as the burning of bark and wet wood refuse.

BIGELOW-LIPTAK *Corporation*

UNIT-SUSPENDED WALLS AND ARCHES

In Canada: BIGELOW-LIPTAK OF CANADA, LTD., *Toronto, Ontario*



DRYER FURNACES

A tough assignment for a furnace is to stand up under the every-day beating of heat in drying applications. B-L's streamlined thin wall dryer furnace does it—cuts maintenance to boot. It furnishes heat for drying coal, sugar, salt, lumber, chemicals.

BIGELOW-LIPTAK *Corporation*

LOWEST MAINTENANCE

When you specify a B-L furnace enclosure you can be sure of long life and lowest possible maintenance. Intelligent engineering and top-quality materials provide the stand-up stamina that makes enclosures "tougher than blazes." Each unit is individually designed for the job. Write today for complete information.

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B-L's castable lining for oil refining furnaces provides a smooth monolithic wall capable of resisting abrasion and standing up under high heat demands. The construction is adaptable to catalytic regenerators, catalytic reactors, cyclones, stacks and other refinery equipment.

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BOOKLETS —Starts on page 68

"ALLIS-CHALMERS PROTECTED DISTRIBUTION TRANSFORMERS," eight-page bulletin 61B7309B, tells how protected distribution transformers help the utility. Operating advantages of the transformer, available in ratings of 3 through 100 kva, 2400 to 14,400 v, and mechanical data on five type designations are also given. Typical load-time curve for one of the units shows how the integral breaker increases useful capacity. *Allis-Chalmers Mfg. Co., Dept. CE, 943 S. 70th St., Milwaukee, Wis.*

SOLENOID VALVES—If you specify direct operated solenoid valves for automatic or remote flow control of liquids and steam up to 400 F or of high viscosity liquids you will want to read 11-page bulletin V-2. Normally closed, normally open, explosion-proof normally closed, and three way valves are shown in cross-sectional drawings with tables of sizes and dimensions. *The Johnson Corp., Dept. CE, Three Rivers, Mich.*

"RLM STANDARD SPECIFICATIONS FOR INDUSTRIAL LIGHTING UNITS, 1955," including the new, higher specifications for both incandescent and fluorescent industrial lighting units effective October 1, 1954 are now available from *RLM Standards Institute, Suite 818, 326 W. Madison St., Chicago 6, Ill.*

"WIRE AND CABLE FOR STREET LIGHTING," 15-page booklet 19-294, is designed to help consultants select the type of cable best suited to a particular installation. Both series and multiple street lighting circuits are discussed. Data is given on general types of cables for direct burial, and for use in conduit, duct, or open-air. *General Electric Co., Construction Material Div., Wire and Cable, Dept. CE, Bridgeport 2, Conn.*

MULTI-V-DRIVES—This 100-page master engineering manual presents scientific and simplified methods for rating V-belts. In addition to accepted theories on V-drive engineering, factors such as small diameter sheaves, centrifugal force, average hours per day operation, and other conditions effecting belt lines have been considered. *Worthington Corp., Mechanical Power Transmission Div., Dept. CE, Oil City, Pa.*

ENCLOSED CONDUCTOR SYSTEMS known as the Insul-8-Bar, for the safety electrification of crane and monorails, are fully discussed in 28-page catalog 8-54. It explains principles of operation and shows how this system meets all crane and monorail requirements without the need for special engineering. *Insul-8-Corp., Dept. CE, 1285 Rollins Rd., Burlingame, Calif.*

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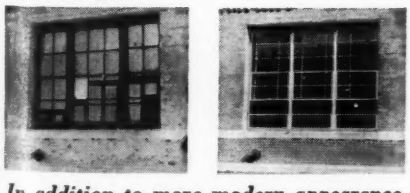

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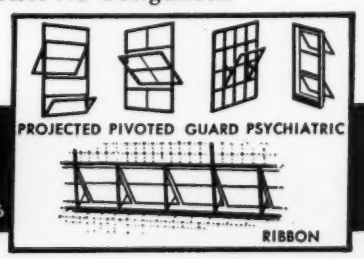

Drafting Skill

—Starts on page 40

the possibility is nothing more than pure snobbery.) With the correct attitude understood from the start, the draftsman can take pride in advancement through the ranks of his own trade in much the same manner as the machinist and electrician.

It cannot be denied that the young engineering graduate should spend a specified period of time on the board (not to exceed six months). During this period he should become thoroughly acquainted with drafting room practices and problems to prepare him to work more effectively with the draftsmen. However, his experience in the drafting room should not be limited to routine chores or to performance of one or two specific tasks.

A close liaison must be established between the engineer and the draftsman. Communication between them should be most informal, taking the form of sketches, written memoranda, and oral directions. The engineer needs to be fully aware of the draftsman's stage of development and his general familiarity with the type of work the engineer is doing. A new draftsman should be extended the same consideration given to a new secretary who is unfamiliar with her boss' habits.

In addition to examining the relationship between engineering and drafting, the consulting office needs to appraise the whole drafting procedure with a view to simplification, speed, and economy.

Many drafting practices are as archaic as the gargoyles on medieval churches and cathedrals. Such practices as the use of hand lettering where typing will do as well; projections and details where a brief description on the drawing will suffice with no sacrifice of clarity; whole views of symmetrical objects when a partial view is adequate; details of parts on assembly drawings; and the failure to use free-hand sketches wherever possible all contribute unnecessarily to the cost of producing a drawing.

Much can be done to simplify drafting practices without sacrificing accuracy or clarity. These simplifications provide substantial savings in cost and time. A number of industrial firms, notably General Electric Company, have adopted simplified drafting techniques and can provide information on actual savings. If the manufacturing industries have found that simplified drafting practices are beneficial, the opportunities for the consulting firm should be even more promising. ▲▲

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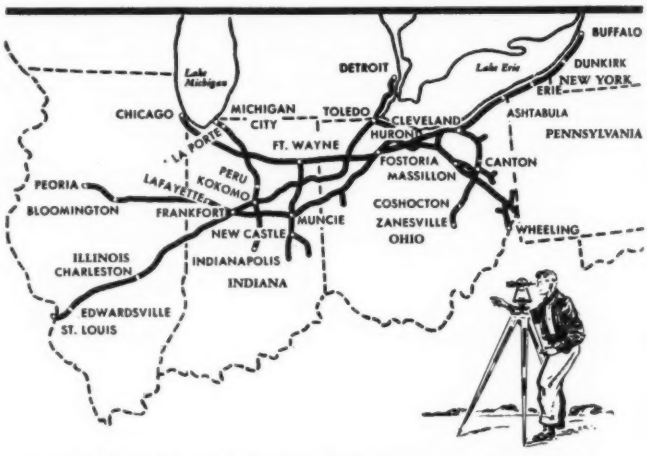

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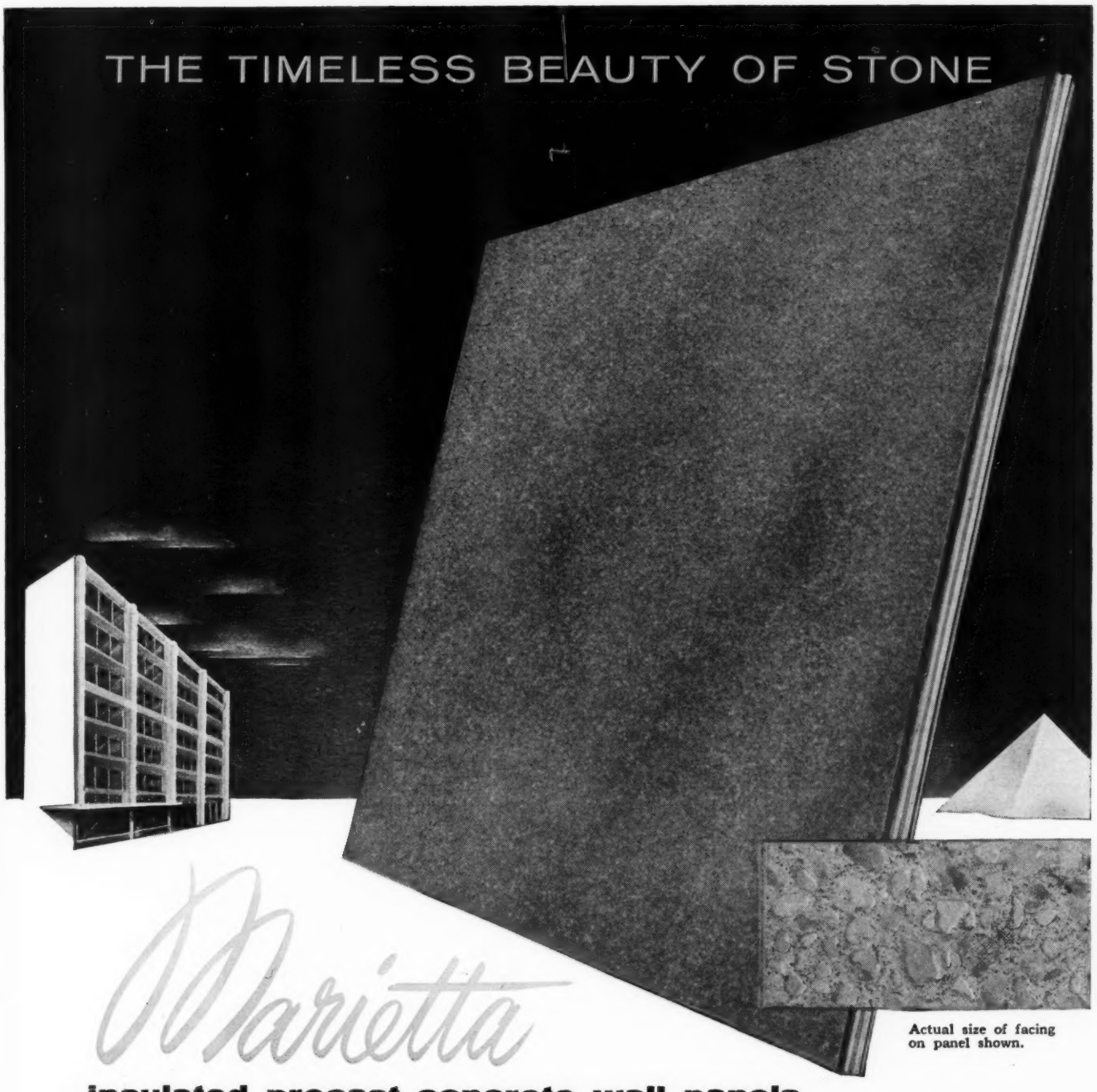

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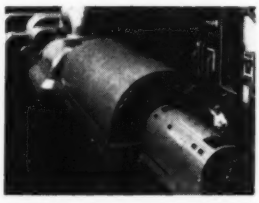
A DESIGNER of factory buildings was interested in theoretical aspects of structural frames. He was approached by a large firm to design and supervise construction of a big plant embodying radical ideas evolved by the client.

The consulting engineer hesitated because he felt that he needed a seasoned supporting team. The fee was augmented in his mind by the value of national publicity that would follow upon completion of such an unusual, large-scale project. He finally accepted the commission under some pressure. The consultant drew up the rough plans.

Doubts began to assail the consulting engineer. He feared that his analysis might not be broad enough. Would contractors bid economically on the nonstandard structure? Would his work stand up under the close scrutiny of national authorities? He meticulously recalculated his preliminary designs. He reached the same conclusions as before, but was still troubled by lack of confidence.

Did he violate professional ethics in taking the job? (If he had declined the challening job, how could he ever have grown in skill and stature?) Should he frankly admit his fears to his client, suggesting that another group be called in jointly or separately? When his doubts began, should he have "sold" himself to a larger group elsewhere, offering his prior knowledge and completed work as considerations of partnership or employment? ▲▲



Inner-Cooling Sets Pace

—Starts on page 42

pated that inner-cooled generators of the future will keep pace with turbine developments, and that a 350-mw to 400-mw unit could be built without undue difficulty. Gas cooling can be developed far beyond the present art without the necessity of resorting to other novel means of direct cooling. While other means can and probably will be developed, the simplicity of inner-cooling with hydrogen appeals currently as the best solution to the problem posed by the present trend toward larger unit ratings.

The challenge is indeed great to reduce electrical losses in every way possible, to use the coolant more effectively rather than circulate excessive and wasteful quantities, and to produce an efficient and competitive product. ▲▲

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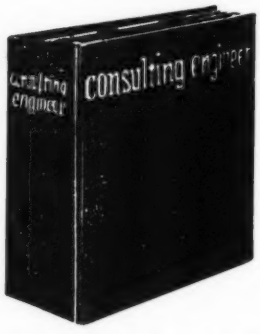

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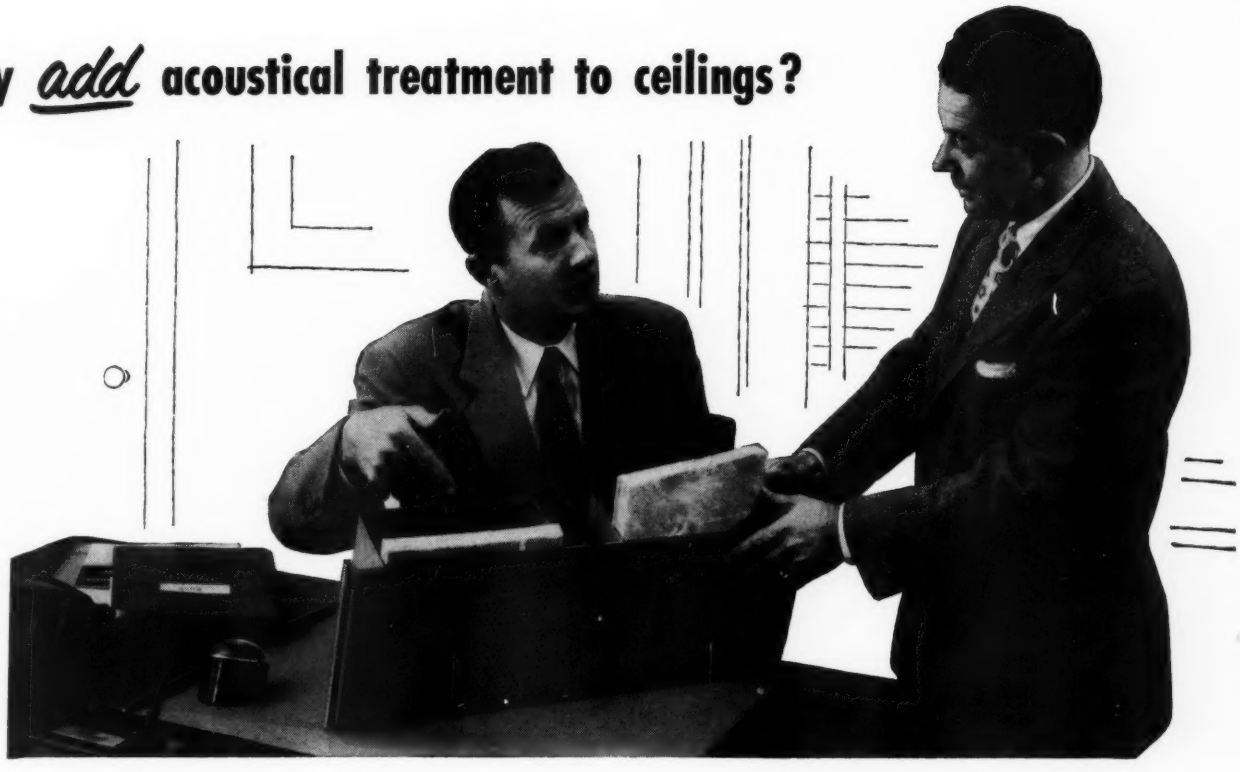

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ANOTHER SCHOOL INSTALLATION in Trumbull Elementary School, Trumbull, Connecticut, uses 14,000 sq. ft. Architect: Lyons & Mather, Bridgeport, Connecticut. Contractor: E. R. Smith, Inc., Stratford, Connecticut.

How to analyze feedback control systems—

This book demonstrates the essential techniques for determining response of linear control systems, with special emphasis on the Root-locus Method invented and developed by the author. This method is particularly useful for complicated systems or those requiring complete solution.

The type of problem covered ranges from the change of speed in a motor to a suddenly applied voltage up to the inter-action of the roll and yaw motions of an airplane. In addition, each solution establishes a concept which permits a simpler technique to be applied to the next more complicated problem. The main feature of the author's presentation is that the physical picture of a solution is developed first with the mathematics introduced later as needed.

Just Published

CONTROL-SYSTEM DYNAMICS

By Walter R. Evans

Systems Group Leader
Electromechanical Engineering Department
North-American Aviation, Inc.

282 pages, 6 x 9,
282 illustrations, $7.00

The author's Root-locus Method is a new approach to the analysis of linear systems which permits the roots of the characteristic equation to be determined in a simple sketch which shows the effect of the open loop function and the loop gain. The roots in turn permit the transient response as well as the frequency response to be plotted. Engineers using the method have found that the plot itself is usually sufficient to describe the behavior of the system, with plotting the transients unnecessary. The effects of several loops in succession can be visualized by a series of root-locus plots.

Covers —
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- **—rule of Cramer's rule for determinants**
- **—transfer matrix concept for coupled systems**
- **—graphical treatment of noise theory**
- **—Thevenin's Theorem applied to electro-mechanical systems**

The opening sections of the book describe the overall problem and the characteristics of typical components; the final sections discuss the treatment of arbitrary inputs and simple nonlinear systems. **Throughout the author emphasizes physical understanding** of the problems as contrasted with memorizing a routine for solving particular problems.

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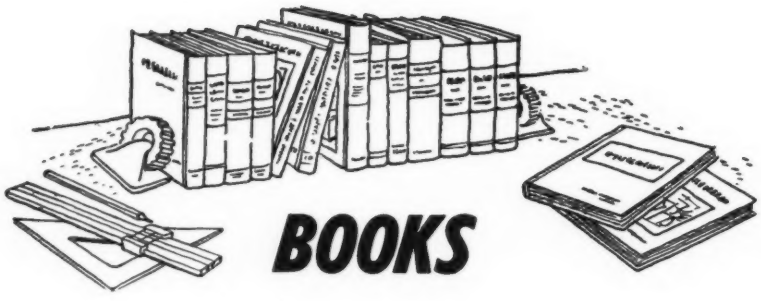

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PROCEEDINGS, SEMINAR on OPERATIONS RESEARCH; Railway Systems and Procedures Association; 131 pp; $4.50.

Reviewed by Dr. Gerald J. Matchett
Illinois Institute of Technology

The *Proceedings, Seminar on Operations Research* contains papers delivered by experts in the field before a three-day seminar sponsored by the Railway Systems and Procedures Association. While the purpose of the seminar was to examine contributions that Operations Research can make to the railroad industry specifically, this book will be of value to all who are interested in the techniques of Operations Research. In fact, several papers contain case studies taken from a variety of manufacturing enterprises.

Five papers show how Operations Research can be applied to the analysis of maintenance-of-way problems involving replacement and life curves of rails and ties, studies of rail-truck coordination, and an approach to rolling stock requirements. The cases illustrate methods that may be well applied in other areas.

Consultants interested in Operations Research techniques will find particularly useful the paper describing the nature and cost of an Operations Research program, presented by Dr. Ellis Johnson, director of the Operations Research office. Another paper discusses the types of specialists that should be included in a well-balanced Operations Research team.

Dr. Johnson estimates that a company can afford to spend between one-tenth and one-seventh of its research budget in Operations Research. He estimates that the cost of supporting one OR man is about $20,000 a year, including an allowance for overhead. Since Dr. Johnson argues strongly that a five-man group is the minimum for effective analysis, he feels that smaller companies can obtain the greatest value by drawing upon consulting firms for the application of Operations Research techniques.

Consultants who are interested in the nature and techniques of Operations Research will find this small volume to be of value.

•

METHODS OF REASONING by P. D. Scott; Cleveland Engineering Society; 16 pp, paper bound; $1.00.

Here is an evening's reading that undertakes to condense, popularize, and clarify the scientific method. The work of logicians, scientists, philosophers, and theologians has been fitted together to create an approach to the solution of modern problems. Beginning with the basic concepts of reasoning, the author covers the ideas of sensed difficulty, techniques for establishing the nature of the problem, formulation of an approach, and methods for arriving at sound solutions.

The type is small and somewhat hard to read. The pages are a bit busy with headings and subheadings. But the author addresses his reader in a compelling manner that is bound to stir the mental habits of most engineers.

TIMING ENGINEERING by Myrten G. Saake; Ribble Engineering Company; 238 pages; $5.00.

Reviewed by Thomas H. Bloodworth, Engineer-in-Charge, Industrial Control Design, Allis-Chalmers Mfg. Co.

This book presents detailed information on design, construction, and usage of industrial timers from the design engineers' point of view. It is especially timely with today's trend towards greatly increased automation in all industries.

The first chapter explains what industrial timing devices are and why they are necessary in many of today's processing methods. Very detailed descriptions of the construction and application of synchronous-motor-operated timers is contained in six chapters. Throughout these chapters, the "how-to-do-it" theme is emphasized. Basic structures of a variety of timers are studied, from the simplest to the most complicated multi-contact devices. Approximately 150 wiring diagrams and time charts are given, covering a wide range of timing relay combinations and applications, which should make this reference the control engineers' text book for the solution of such timer problems.

Chapter VII describes briefly the problems of timing where only d-c power is available. It lists methods whereby synchronous-motor-driven timers can be operated from d-c supplies. Chapter IX lists other types of timing devices and explains why the bulk of the text is devoted to synchronous-motor-driven timers.

The value of this book to industrial control design engineers possibly would be increased if competitive types of timers were described.

ALSO AVAILABLE

MACHINERY'S HANDBOOK, Fifteenth Edition; The Industrial Press; 1911 pages; $9.00.

The first edition of *Machinery's Handbook* appeared in 1914, and 14 new editions have appeared since then. Now a 15th edition is available bringing together the most recent basic information, data, and formulas for the potential handbook user.

The new edition includes a revised and rearranged spur gear section and an entirely new section on generated bevel gears. The spur gear section features an enlarged presentation of standard definitions and terms as well as an enlarged set of data and design information.

Important changes in the dimensions of American Standard square and hexagon bolts and nuts are summarized, with a table comparing the old and new across-flats dimensions. Complete tables giving the standard sizes and limiting dimensions of the various types of nuts and bolts are also included. In the materials section, new data on nickel and nickel alloys, titanium and titanium alloys, and copper-silicon and beryllium alloys are presented.

•

NATIONAL FIRE CODES, in six volumes; National Fire Protection Association; $6.00 per volume.

The Codes are a compilation of 162 safety standards developed by NFPA. They are published in six volumes: Flammable Liquids and Gases (672 pp); Combustible Solids, Dusts, Chemicals, and Explosives (512 pp); Building Construction and Equipment (640 pp); Extinguishing Equipment (640 pp); Electrical, comprising the National Electric Code plus six NFPA standards (672 pp); and Transportation (424 pp). The new edition represents a complete revision of the 1938 issue. It would be of great value to any engineer designing facilities that come within the realm of the Codes.

•

INDUSTRIAL ENGINEERING, A Productivity Report; British Productivity Council; 116 pp; price on application.

This is the report of a British industrial team that came to the United States to study American production methods. The purpose of the study was to compare production techniques of the two countries in order to make recommendations for improving productivity in Great Britain. For the American consulting engineer, the report of the team's observations constitutes a searching, fact-packed appraisal of the industry he is serving.

•

CLIMATIC CRITERIA DEFINING EFFICIENCY LIMITS for CERTAIN INDUSTRIAL ACTIVITIES; U. S. Department of Commerce; 26 reports, each available in microfilm or photocopy form; Summary Report $4.50 (microfilm) or $12.75 (photocopy), all others less expensive.

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This helpful book contains the pattern for professional conduct and cites many unwritten laws of engineering. It shows you how to avoid legal pitfalls and what your rights are under the 5 different groups of laws. You'll find many pertinent tables showing you the yield on extra investment — expenses and their allocation — the public utility rate equation — allocation of burden, etc, etc. This book explains basic principles and fundamentals clearly and concisely . . . covers everything from the way a business is organized to insurance, industrial hazards and employment compensation.

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